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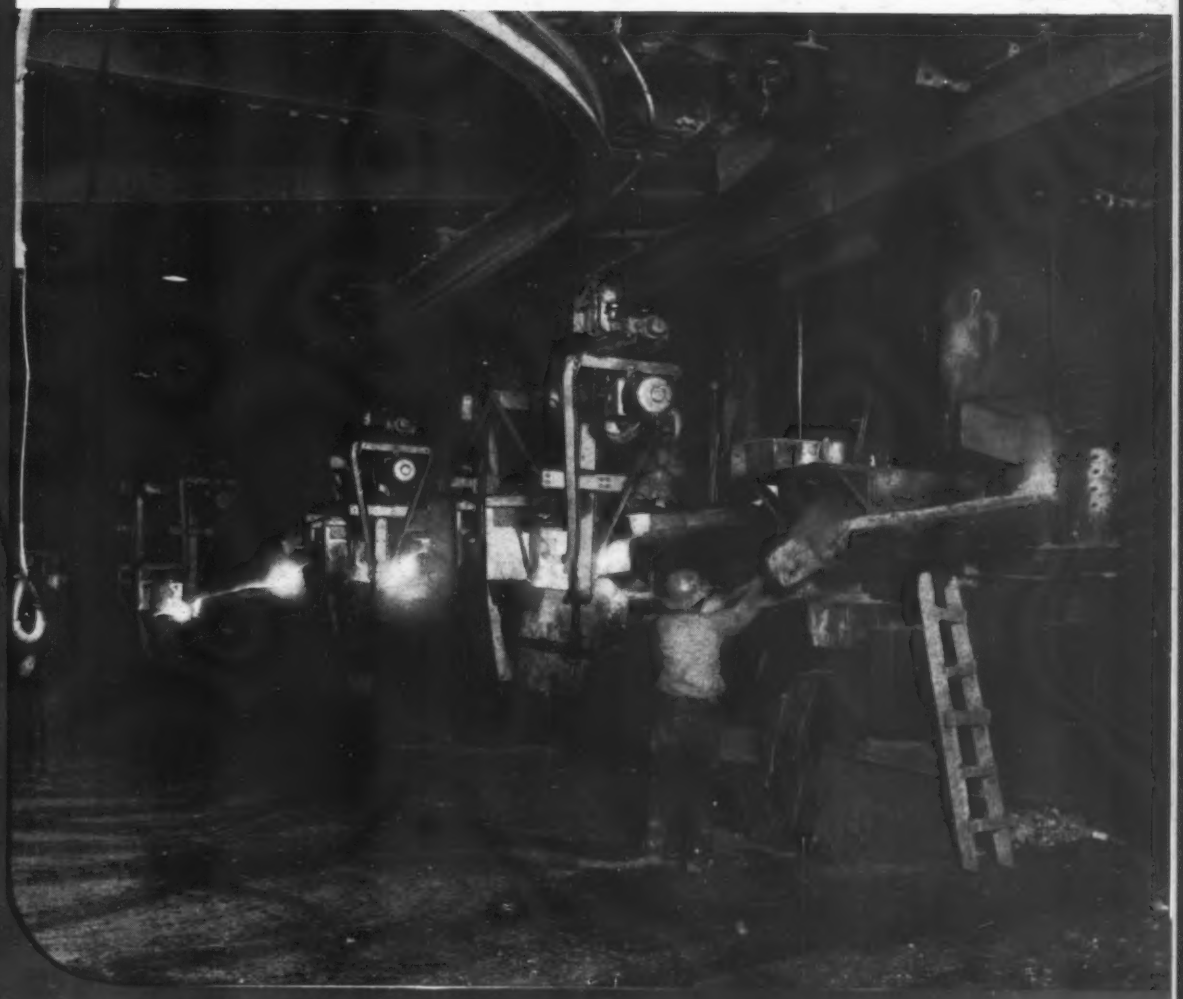
American Foundryman

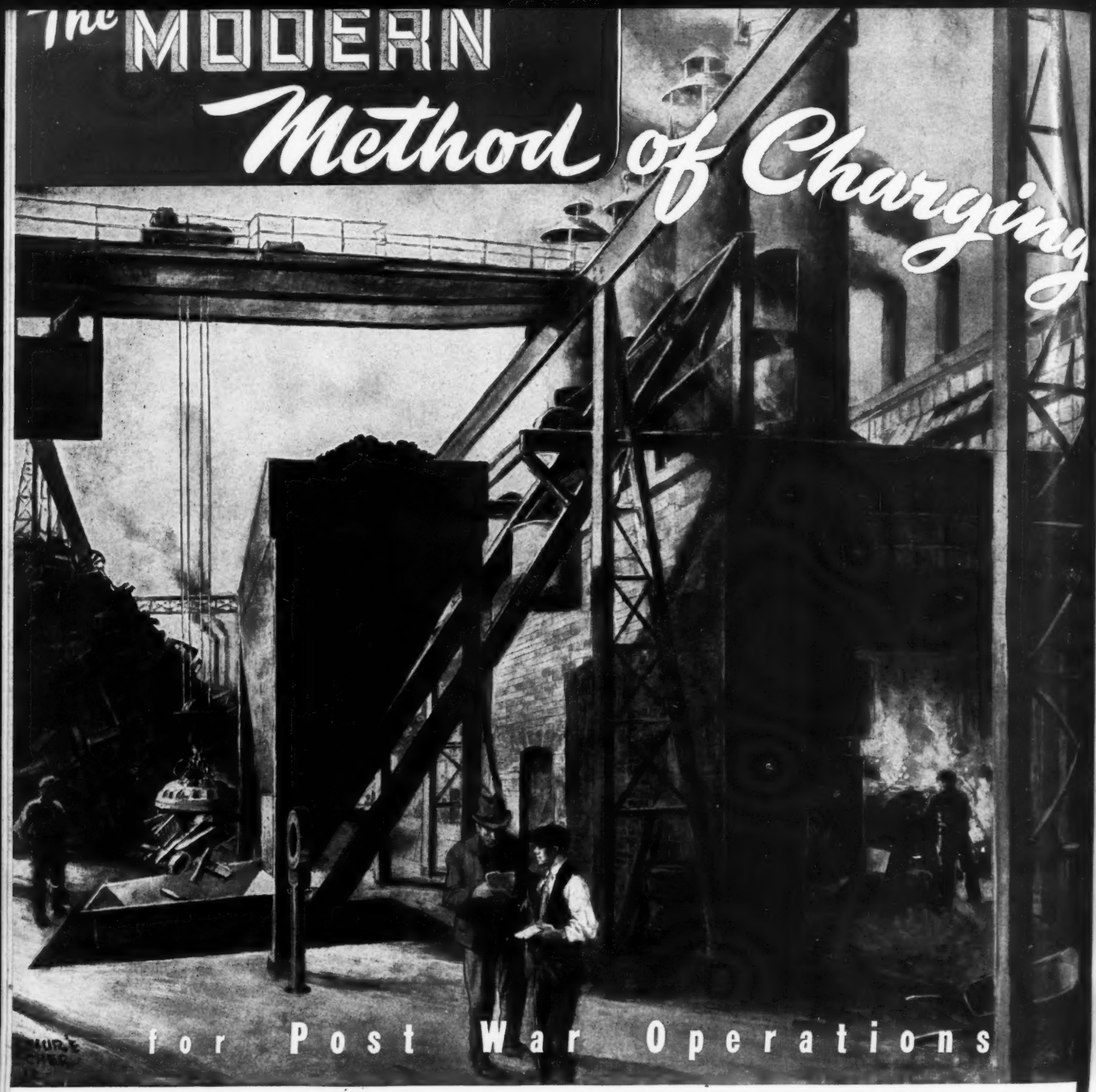
"The FOUNDRYMEN'S OWN MAGAZINE"



Tapping a battery of cupolas.

October 1945—Bronze Castings (p. 24). Industrial Engineering Programs (p. 30). Precision Castings (p. 33). Magnesium Alloys (p. 39). Gamma-Ray Radiography (p. 50). Student Training Plan (p. 62). Sand Control (p. 65). Fluxes (p. 68)

The MODERN Method of Charging



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(See next page.)

K-311

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SEE NEXT PAGE

4-Color Illustration
From Page 30 of "Electro's"
New Handbook Catalog 645

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TRADE MARK
SINCE 1919

Electro HIGH SPEED CUT-OFF WHEELS

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In Catalog 645, "Electro" uses full color and authoritative text to present to Industry, newest grinding wheels and techniques developed during these five years of unprecedented progress in speed and precision. It is the very latest grinding manual.

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American Foundryman

OCTOBER, 1945 VOL. VIII, No. 3

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The American Foundrymen's Association is not responsible for statements or opinions advanced by authors of papers printed in its publications.

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WHO ARE THE AUTHORS *In This Issue?*

The men whose names are shown on these two pages deserve the thanks of the industry for their contributions to the 1945 "Year-'Round Foundry Congress" . . . In many cases, completed in spite of cancellation of the Detroit convention.

J. D. Hanawalt

See paper on *"Properties and Characteristics of Common Magnesium Casting Alloys,"* authored by Mr. Hanawalt and associates C. E. Nelson and R. S. Busk . . . Born in Royersford, Pa. . . . A graduate of Oberlin College, Oberlin, Ohio, 1924 . . . Obtained his PhD from the University of Wisconsin, Madison, 1929 . . . Held National Research Fellowship for two years . . . Studied at University of Michigan, Ann Arbor, and University of Groningen, Holland, specializing in x-ray spectra . . . Began his industrial career with his present firm, Dow Chemical Co., Midland, Mich., in 1931 . . . Since 1940 has been director of metallurgical department . . . Has prepared technical papers for many technical societies . . . Nature of subjects include corrosion, alloying and x-ray diffraction of magnesium alloys . . . Member of American Chemical Society, ASTM, ASM, AIME, and A.F.A.

W. E. George

Author of paper in this issue on *"Plant Management's Part in Industrial Engineering Problems"* . . . A native of Indiana, being born in Indianapolis . . . Received his bachelor of science degree in civil engineering from Georgia School of Technology, Atlanta, Ga., 1921 . . . Became associated with Illinois Central Railroad, Fort Dodge, Iowa, as a rod man following graduation . . . Two years later (1923) joined Certain-teed Products, St. Louis, as assistant purchasing agent . . . Joined the Imperial Brass Mfg. Co., St. Louis, in 1926 as sales engineer . . . For three years was supervisor, Haynes Corp., management engineers, Chicago . . . During 1931 became chief industrial engineer, American Steel Foundries, Chicago . . . Was affiliated with Campbell, Wyant & Cannon Foundry Co., Muskegon, Mich., for six years as assistant to management . . . Now employed by Booz, Allen & Hamilton, Chicago, as an account manager . . . Has written for the trade press and meetings of various technical societies . . . Subjects include wage incentives, job evaluation, budget control, and other related subjects . . . Last year served as vice-chairman, Job Evaluation and Time Study Committee, and also was a member of the Foreman Training Committee . . . Is a member of Society for Advancement of Management, Industrial Management Society, and A.F.A.

R. H. Frank

Author of, in this issue, *"Advantages and Limitations of Gamma-Ray Radiography in Small Steel Castings"* . . . Born in Columbus, Ohio . . . Obtained his bachelor of arts degree from Ohio State University, Columbus, in 1920 . . . Has been associated with the Bonney-Floyd Co., Columbus, since graduating from college . . . At present is chief metallurgist . . . A member of A.F.A. Committee on Non-destructive Testing . . . Member of Electric Metal Makers Guild, Steel Founders' Society of America, ASM, ASTM, and A.F.A.

P. G. Griebel

Plant Coordinator for the high school cooperative program, Caterpillar Tractor Co., Peoria, Ill. . . . Author of paper in current issue *"Caterpillar Cooperates in Training High School Students for Foundry Work"* . . . Born in Chicago, December, 1919. . . . Graduated from Illinois Institute of Technology, Chicago, in 1942 . . . Affiliated with Electric Service Engineering Co., Chicago, until 1942 on a part time basis . . . Became associated with Caterpillar in 1942 . . . A graduate of Caterpillar's college graduate training program . . . During the war emergency prepared and presented training programs on such subjects as tool design, metallurgical work, hydraulics and other engineering courses . . . Now in the special training division, Training Department, he has been plant coordinator since 1944.

H. L. Womochel

Research assistant for Engineering Experiment Station, Michigan State College, East Lansing, Mich. . . . Part author with C. C. Sigerfoos on paper *"Relative Effect of Lime and Dolomite Fluxes on Cupola Irons and Cupola Operation"* . . . Holds a master of science degree in metallurgy from University of Wisconsin, Madison . . . Started his industrial career with John Deere Plow Co., Moline, Ill., as chemist, in 1929 . . . Became associated with Burgess Parr Co., Freeport, Ill., as

DISCUSSION WANTED!

•

The men who are recognized on these Who's Who pages each month have spent considerable time and effort in preparing their papers for presentation herein, and the value of their findings can be materially enhanced through discussion. Since oral discussion is not possible this year, written discussion is earnestly solicited!

Members of A.F.A. owe it to these authors to take a definite interest in their work. Written discussion should be forwarded direct to A.F.A. headquarters in Chicago, for publication in future issues of *American Foundryman*.

chemist and metallurgist two years later . . . Was connected with Battelle Memorial Institute, Columbus, Ohio, as research metallurgist from 1937-38 . . . Is a member of the A.F.A. Subcommittee on Slags, Fluxes and Desulphurizers . . . Member of A.F.A.

Capt. W. A. Morey

See: *"Industrial Status of Precision Castings"* . . . Author educated at Colorado School of Mines, Golden, Colo. . . . Affiliated with United States Gypsum Co., Chicago, as research engineer following graduation . . . Assumed position of patent attorney with Mann & Brown, Chicago . . . At present is a captain, U. S. Army, ordnance div., and is in charge of the engineering section, Chicago Ordnance District.

Lt. (j.g.) F. L. Riddell

Author of paper herein on *"Sealing Bronze Pressure Castings Through Heat Treatment"* . . . A native of Chicago, born there in 1921 . . . Received his bachelor of science degree in metallurgical engineering from University of Illinois, Urbana, Illinois, 1943 . . . Obtained his ensign's commission in the Naval Reserve during 1943 . . . Recently promoted to lieutenant (junior grade) . . . At present is stationed at the Naval Research Laboratory, Anacostia Station, Washington, D. C. . . . A member of AIME and ASM.

C. E. Nelson

Author (with associates J. D. Hanawalt and R. S. Busk) of current paper on *"Properties and Characteristics of Common Magnesium Casting Alloys"* . . . Mr. Nelson was born in Nelsonville, Ohio, in 1907 . . . Graduated from Alma College, Alma, Mich., in 1928 . . . That same year, joined Chevrolet Motor Co., Flint, Mich., as metallurgist . . . The following year, accepted position of research chemist at E. I. Du Pont de Nemours Co., Wilmington, Dela. . . . In 1930 became affiliated with Dow Chemical Co., Midland, Mich. . . . Appointed metallurgist, he has since been made assistant director of metallurgical research (1942).

C. C. Sigerfoos

Co-author, with H. L. Womochel, of A.F.A. paper on fluxes in this issue entitled: *"Relative Effect of Lime and Dolomite Fluxes on Cupola Irons and Cupola Operation"* . . . Mr. Sigerfoos was born in Elkhart, Ind., in 1908 . . . In 1930 he received a bachelor of science degree in mechanical engineering from Purdue University, Lafayette, Ind. . . . Obtained his master of science degree in 1935 from the same institution . . . Became an instructor on foundry practice at Purdue University in 1930 . . . Three years later held a similar position at the Manual Training High School, Indianapolis, Ind. . . . Assumed his present position as instructor of foundry practice at Michigan State College, East Lansing, Mich., in 1935 . . . Is a member of A.F.A.

R. S. Busk

Metallurgist for Dow Chemical Co. . . . Part-author of paper in this issue on *"Properties and Characteristics of Common Magnesium Casting Alloys"* . . . Co-authors J. D. Hanawalt and C. E. Nelson . . . Mr. Busk is a native of Brooklyn, N. Y. . . . Merited a bachelor of arts degree from Colgate University, Hamilton, N. Y. . . . At Yale University, New Haven, Conn., earned the degree of doctor of engineering . . . Became associated with Dow Chemical Co., as metallurgist in their Midland, Mich., plant in June, 1940 . . . Well known for his work in magnesium metallurgy . . . Has prepared papers on this subject before meetings of ASTM, AIME, and A.F.A. . . . Also a member of ASM.

G. Davis

Author of paper on *"Sand Control in the Malleable Iron Foundry"* . . . Began his industrial career with International Harvester Co., Canton, Ill., in the accounting department . . . Was transferred to the forge shop and heat treatment department for a year . . . Worked in the metallurgical department for five years and was appointed works metallurgist in 1930 . . . From 1934 to 1936 was assistant foundry superintendent . . . In 1937 and 1938 worked out of the plant superintendent's office . . . Late in 1938 helped erect a manufacturing plant at Geelong, Australia . . . Returned to the United States in 1942 and was made assistant works metallurgist, McCormick Works, Chicago . . . A year later was named assistant superintendent, malleable foundry, McCormick Works.

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Ajax Plastic Bronze
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Ajax Manganese Bronze
Ajax High-Tensile Manganese Bronze
Ajax Golden Glow Yellow Brass
Ajax Nickel-Copper 50-50%
Ajax Manganese Copper
Ajax Aluminum Alloys
Ajax Phosphor Copper
Ajax Silicon Copper
Ajax Nickel Alloys
Ajax Phosphor Tin

NOTE

"Proper Melting Decreases Foundry Losses," contains interesting data. Also, the booklet, "Nonferrous Ingot Metals of Today." Write for both of these. They are free.

Successful foundrymen deoxidize or "clean up" molten metal by a scientific method worth using *as indicated:*

They use phosphorus . . expertly . . in the form of "Ajax Phosphor Copper" . . added as the crucible is removed from the furnace . . for virtually all brass and bronze alloys.

In notched waffle sections, or in shot form, Ajax 15% P-Cu does its work at .01% (1 oz. per 100 lbs.). Introduced, and having time to react when stirred with a whirling motion of the skimmer, it causes oxides to rise for effective removal by skimming from the surface. It is best to avoid phosphorus build-up from back stock.* . . If you use phosphorus these days, use Ajax Phosphor Copper (useful also in producing your phosphor bronze)

THE **AJAX** METAL COMPANY
ESTABLISHED 1880 PHILADELPHIA

ASSOCIATE COMPANIES:
AJAX ELECTRIC FURNACE CORPORATION, *Ajax-Wyatt Induction Furnaces for Melting*
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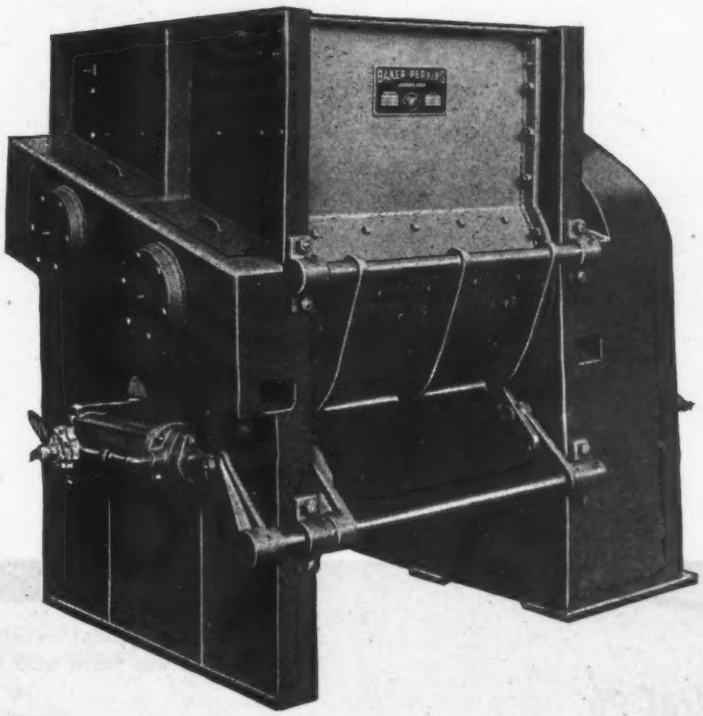
AJAX ELECTRIC COMPANY, INC., *Electric Salt Bath Furnaces*
AJAX ENGINEERING CORPORATION, *Ajax-Tama-Wyatt Aluminum Melting Furnaces*

WHAT THEY SAY ABOUT BAKER PERKINS CORE SAND MIXERS

MEMBER



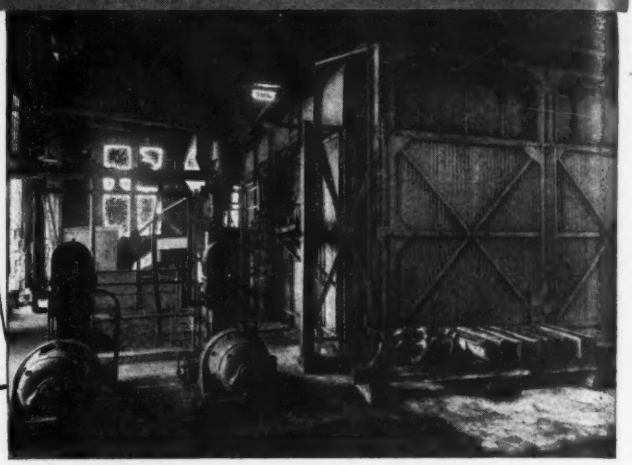
Workmen who operate them like the simple, labor-saving operation of Baker Perkins "Unidor" Core Sand Mixers. Baker Perkins Mixers mull, stir, and knead all in one operation, and they do not require any special aerating attachments. Result? They consistently produce sand batches of uniformly high quality with a minimum of labor.

Production Men rely on Baker Perkins "Unidor" Mixers because their swift action in preparing core sand gets any job of casting off to a flying start. They help assure uninterrupted foundry production because they deliver a thorough, homogeneous sand mix of greater permeability which improves casting quality and reduces chances of spoilage. "Unidor" Mixers can be loaded by weighing hoppers or power skip-hoists to suit the production set-up.

Foundry Managers endorse Baker Perkins "Unidor" Mixers because their high operating efficiency means a savings in production costs without sacrificing casting quality. "Unidor" Mixers distribute uniformly a thin layer of bond around each of the sand grains, assuring 100% benefit from the bonds, binders, oils, seal coals, pitch, or other compounds used. "Unidor" Mixers require practically no maintenance other than routine lubrication and occasional renewal of easily replacable steel liners and hardened steel wearing shoes. For further facts call or write Baker Perkins Inc., Foundry Equipment Sales Division, Saginaw, Michigan.

BAKER PERKINS BUILDS EFFICIENT FOUNDRY EQUIPMENT

Superintendent "We Have Been Able



This Hydro-Blast installation at Kutztown increased production from 600 tons to 800 tons per month.

PHONE 330

Kutztown Foundry and Machine Corporation

PRESSURE CASTINGS CHEMICAL EQUIPMENT SPECIAL MACHINERY

KUTZTOWN, PENNSYLVANIA

ADDRESS ALL COMMUNICATIONS TO THE COMPANY

August 10, 1945

The Hydro-Blast Corporation,
2550 N. Western Avenue,
Chicago 47, Illinois

Gentlemen:

You may be interested to know that since installing our Hydro-Blast Unit approximately three months ago, we find that we have been able to increase the tonnage in our foundry approximately 30%, due to being able to clean and ship this increased tonnage with the men available—the bottle-neck before being the lack of manpower.

We also show marked savings in the labor cost per ton for cleaning, and are building up a considerable stock pile of washed sand, which we are re-using for facing and cores.

Since the installation of the Hydro-Blast Unit, the Cleaning House is no longer the dirty, dusty place it was, with the result that the dissatisfaction with working conditions that previously caused no end of annoyance, has been eliminated, and a nasty labor situation solved.

I wish to personally thank your organization for the cooperation and service it has given us, starting with the erection of the Hydro-Blast Unit, and following through with the operation, instruction of operators, and the assistance of your sand technician in solving some of our sand problems.

Very truly yours,

THE KUTZTOWN FOUNDRY & MACHINE CORPORATION

Richard Henderson 3d.

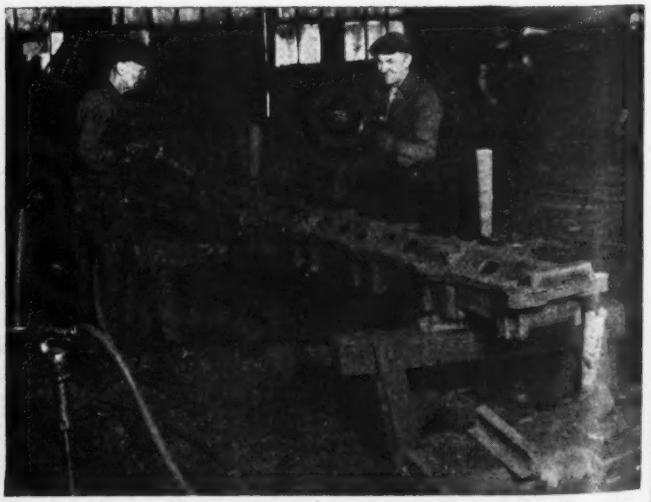
SUPERINTENDENT

RH:os

Partial list of Kutztown castings

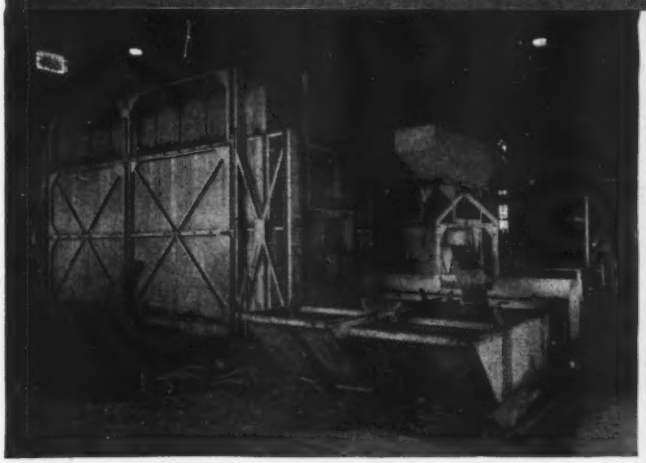
High strength gray iron
Highly alloyed gray iron
Heat resistant gray iron
Chemical equipment
Pressure castings
Special machinery
Condenser castings
Machine tool castings
Ni-resist castings

When a Hydro-Blast user says: "I wish to personally thank your organization for the cooperation and service it has given us, starting with the erection of the Hydro-Blast Unit, and following through with the operation, instruction of operators, and the assistance of your sand technician in solving some of our sand problems"...

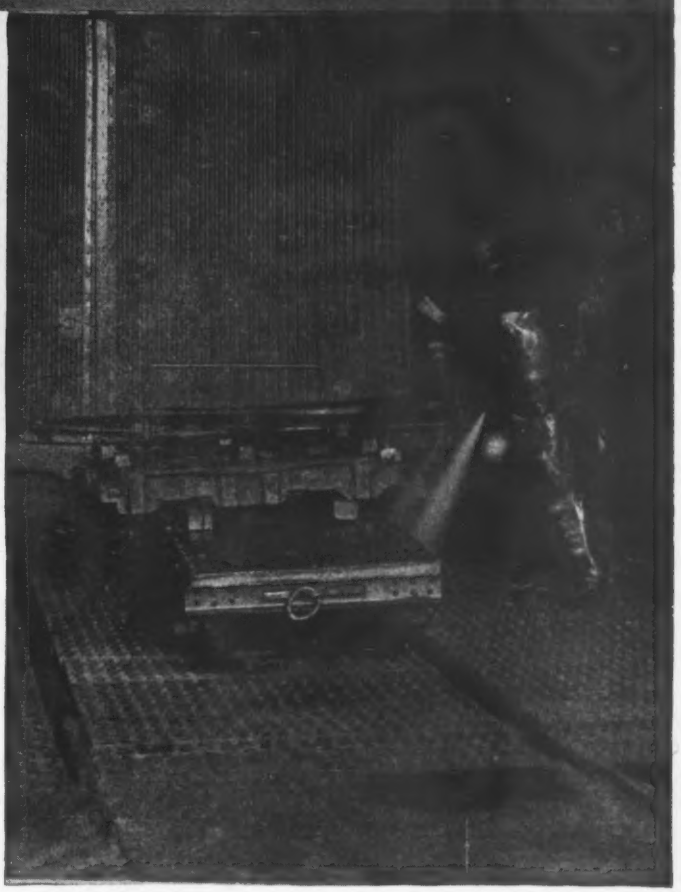


These three photographs show the former cleaning room "bottle neck" which was broken by the installation

Richard Henderson 3rd Says...
to *INCREASE* Tonnage 30%"



Average cleaning time has been reduced on a 5 to 1 ratio — an 80 percent time saving.



Kutztown Foundry and Machine Corporation pours special gray iron castings up to 15 tons.

. . . that means customer satisfaction far beyond the point of sale—and that's what Hydro-Blast assures every user.

Let us give you the performance facts about Hydro-Blast in all kinds of foundries on all kinds of work. Unquestionably, we have installations on work which parallels the job required in your shop.

of the Hydro-Blast wet sand and water method.

HYDRO-BLAST

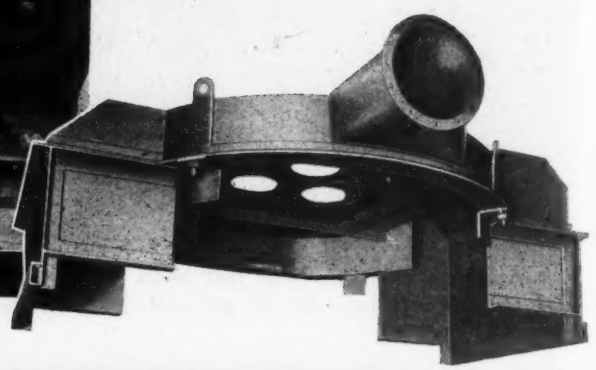
2550 N. WESTERN AVE.
CHICAGO 47, ILLINOIS

ROTO-CLONE DUST AND FUME CONTROL FOR ELECTRIC FURNACES

BEFORE ROTO-CLONE INSTALLATION

ELECTRIC FURNACE EXHAUST HOOD

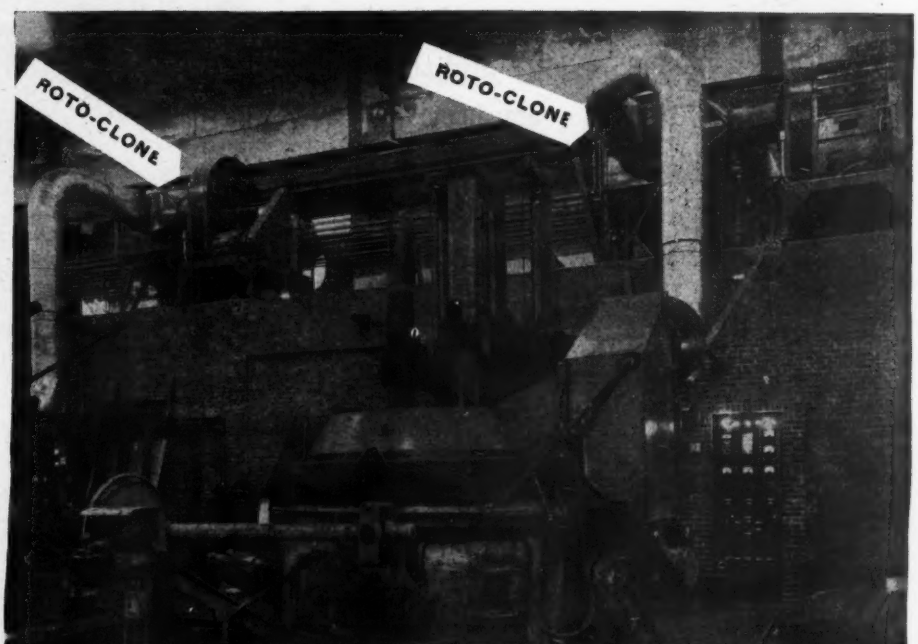
These unretouched photographs are visual evidence of Roto-Clone's efficiency in the control of electric furnace dust. The patented Electric Furnace Hood shown below is designed to fit individual requirements and does not interfere with charging and pouring.



In the foundry where these pictures were taken, two Roto-Clones exhausting 16,000 c.f.m. in combination with the AAF furnace hood completely eliminated the dust nuisance where more than 120,000 c.f.m. of general ventilation utterly failed. Other Roto-Clone advantages include regulation of air volumes up to the maximum required at high temperature peaks and an almost constant inflow of room air regardless of high temperatures. Send for complete information.

AMERICAN AIR FILTER CO., INC.
104 Central Ave., Louisville, Ky.

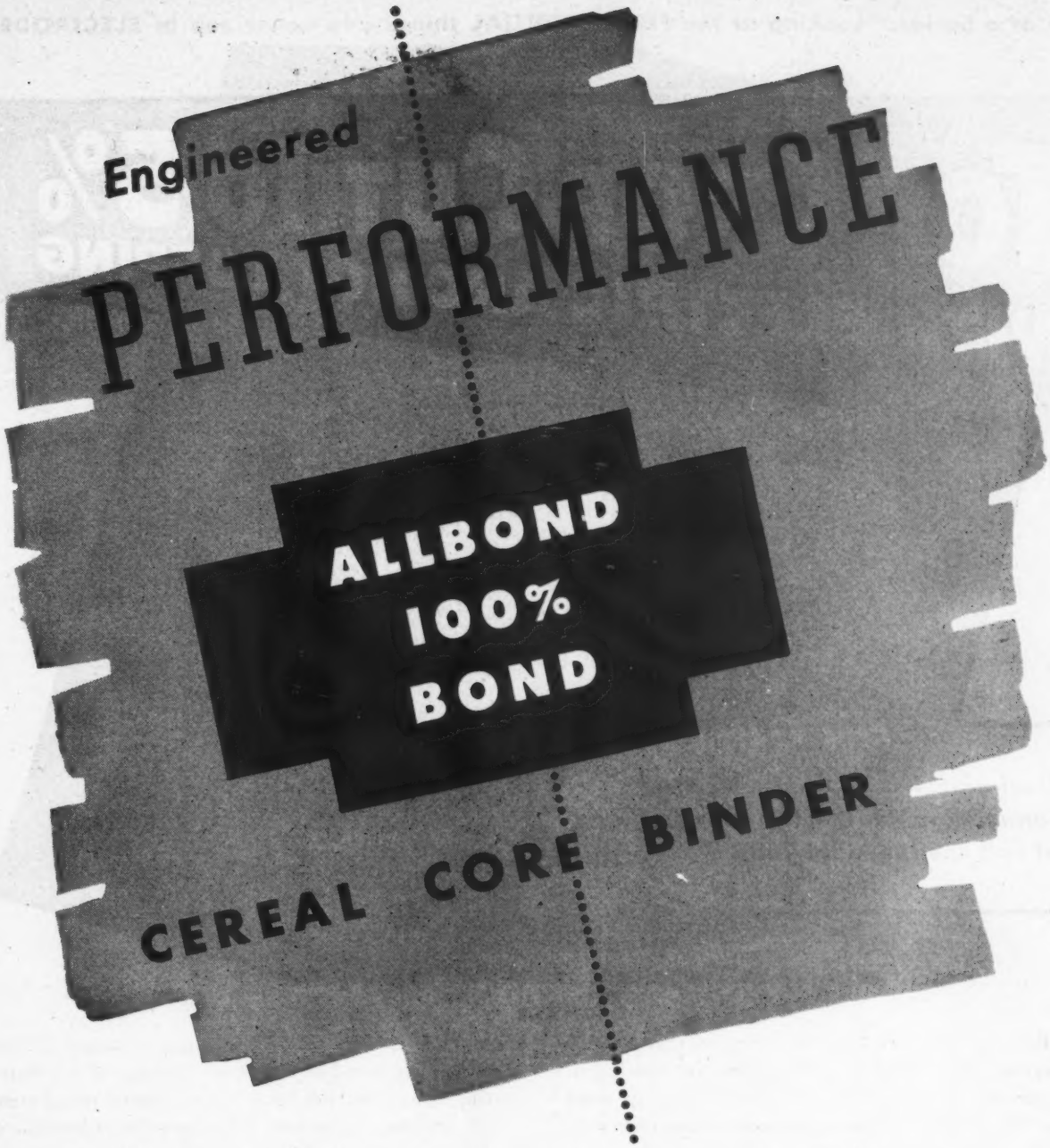
ANOTHER AAF PRODUCT



AFTER ROTO-CLONE INSTALLATION

ROTO-CLONE

For Foundry Dust Control



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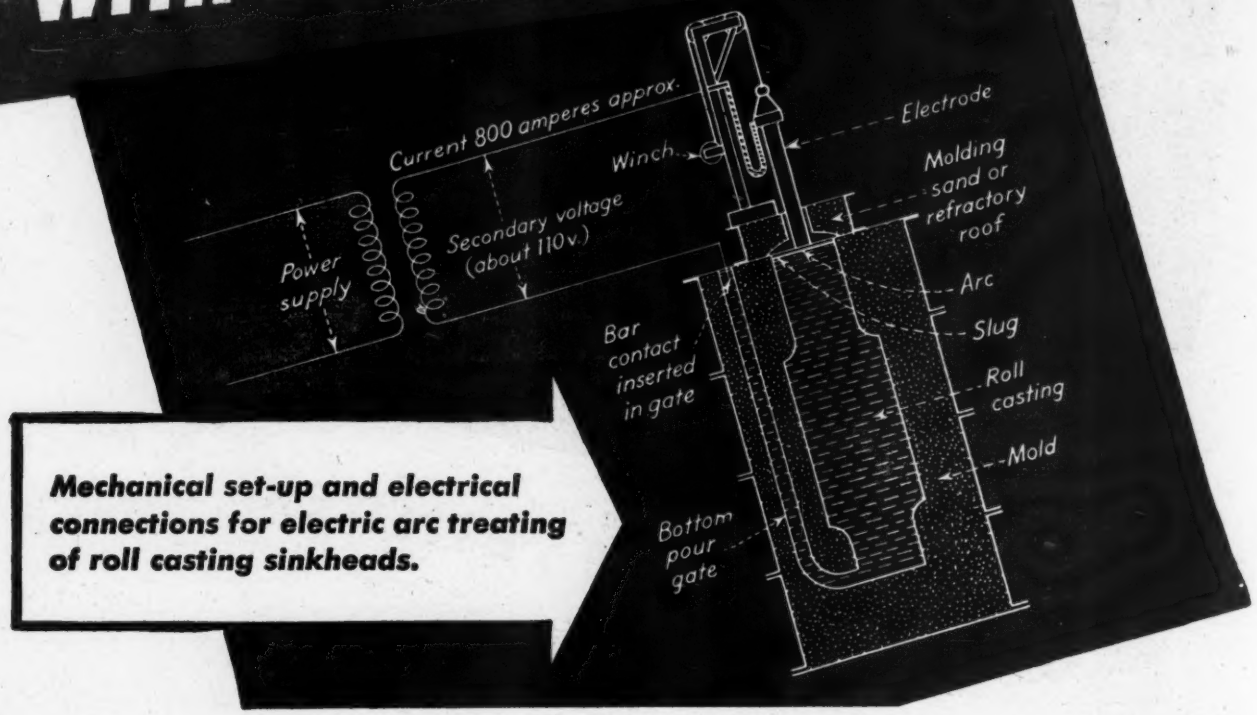

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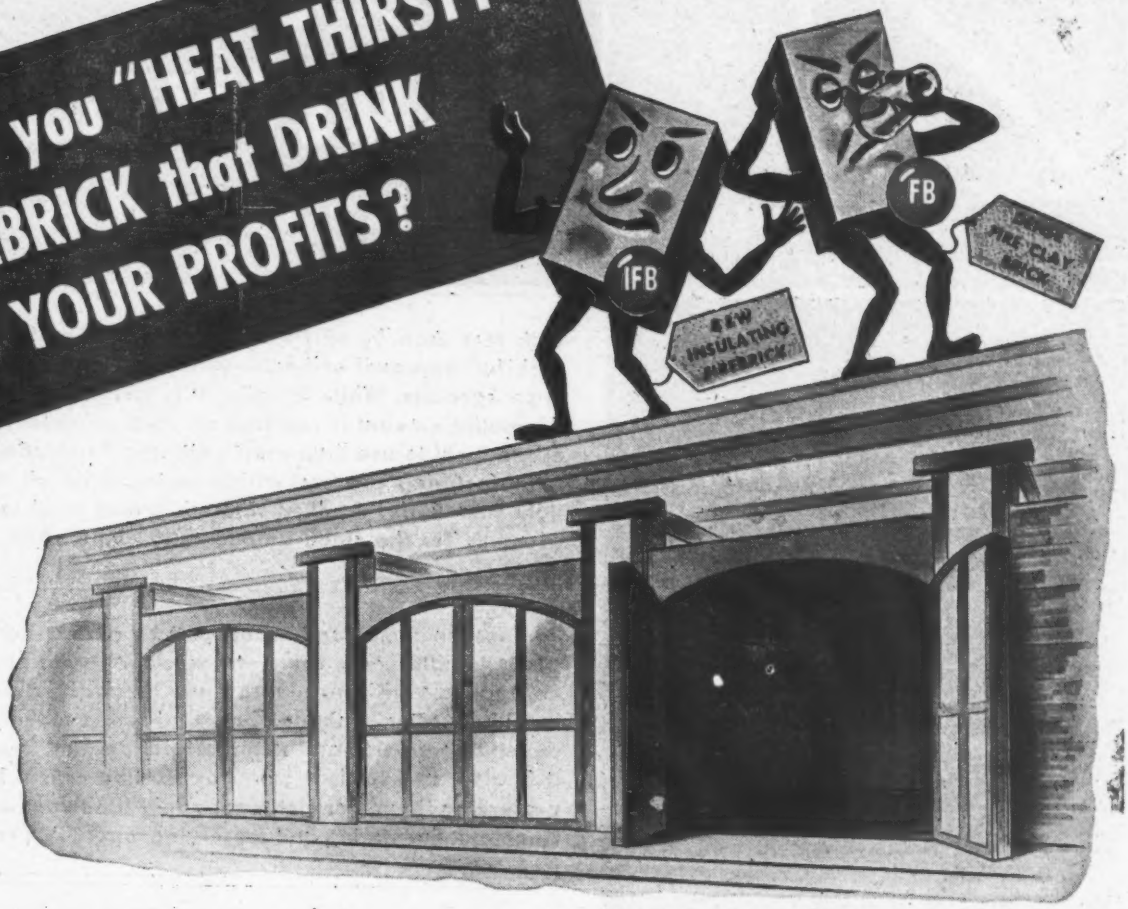

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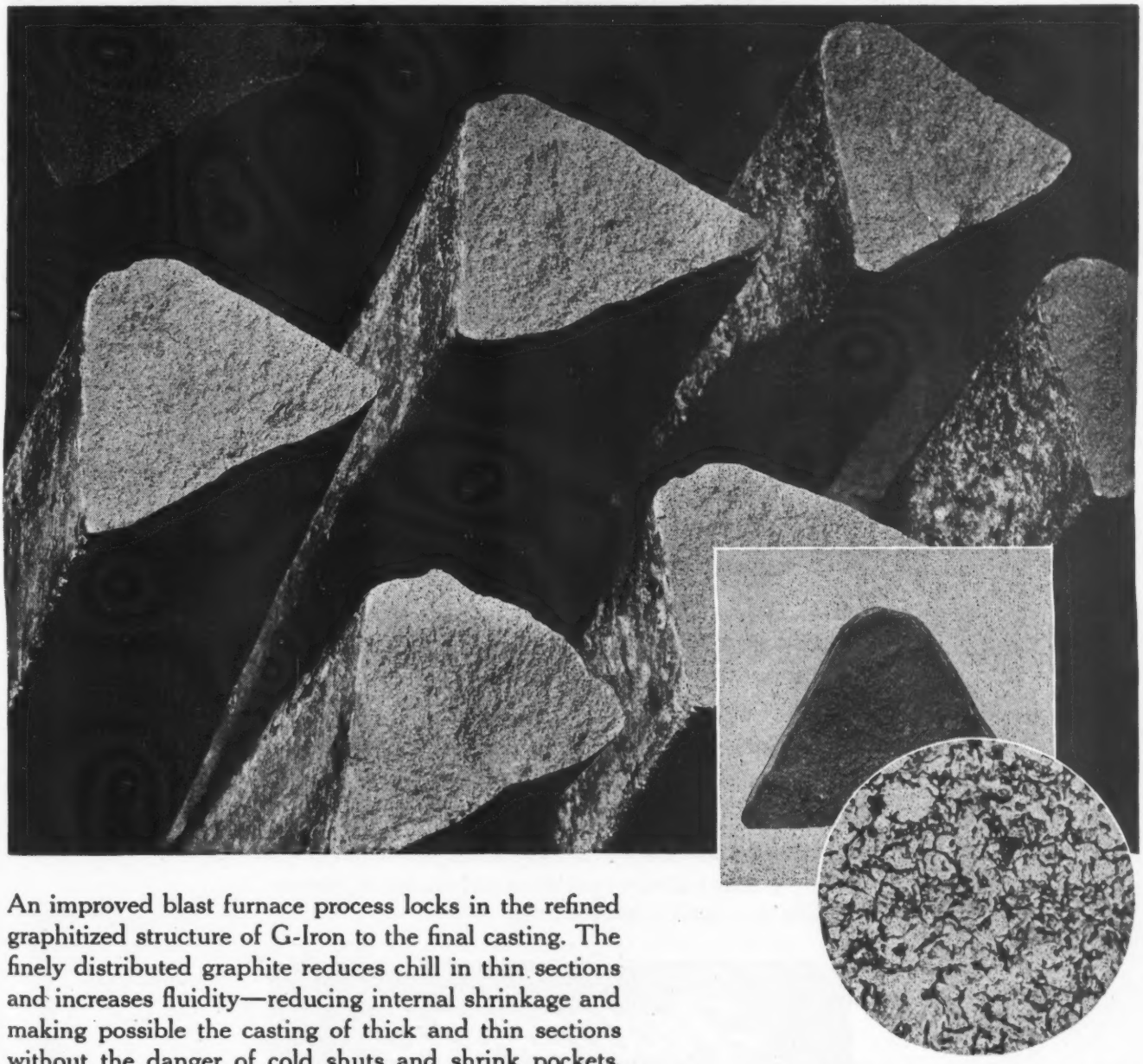

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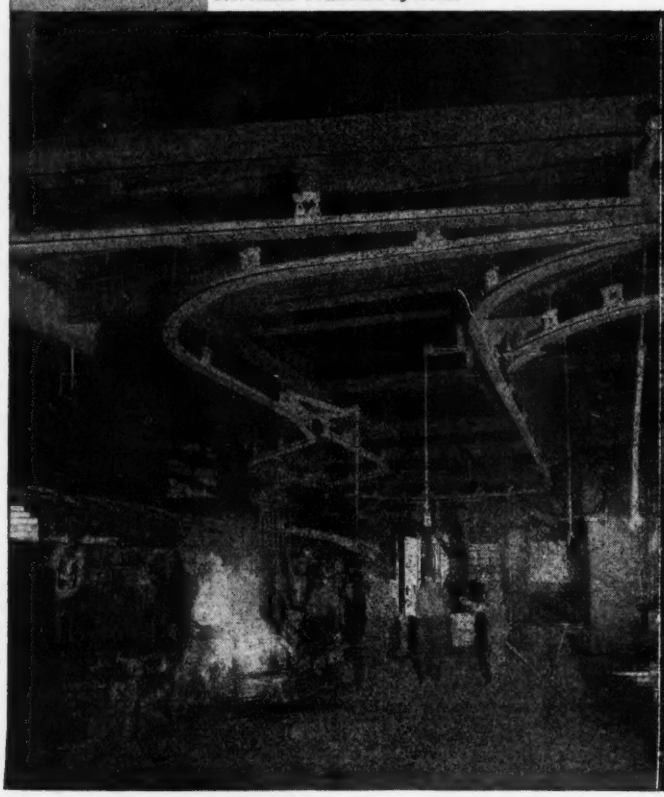
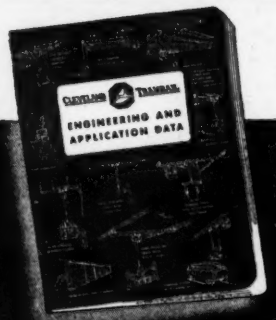
Cleveland Tramrail Equipment is built to withstand the rigors of heat and grime. Terre Haute officials cannot recall ever having trouble of any kind with their system although it is in continuous service. Practically no maintenance is required.

Hot malleable iron is taken directly from the furnace to the molds without rehandling in these 600-lb. ladles over the Cleveland Tramrail System.

The large castings, weighing up to 200 lbs. are poured from two ladles at a time. Each ladle is moved about the pouring floor by means of an individual transfer bridge.





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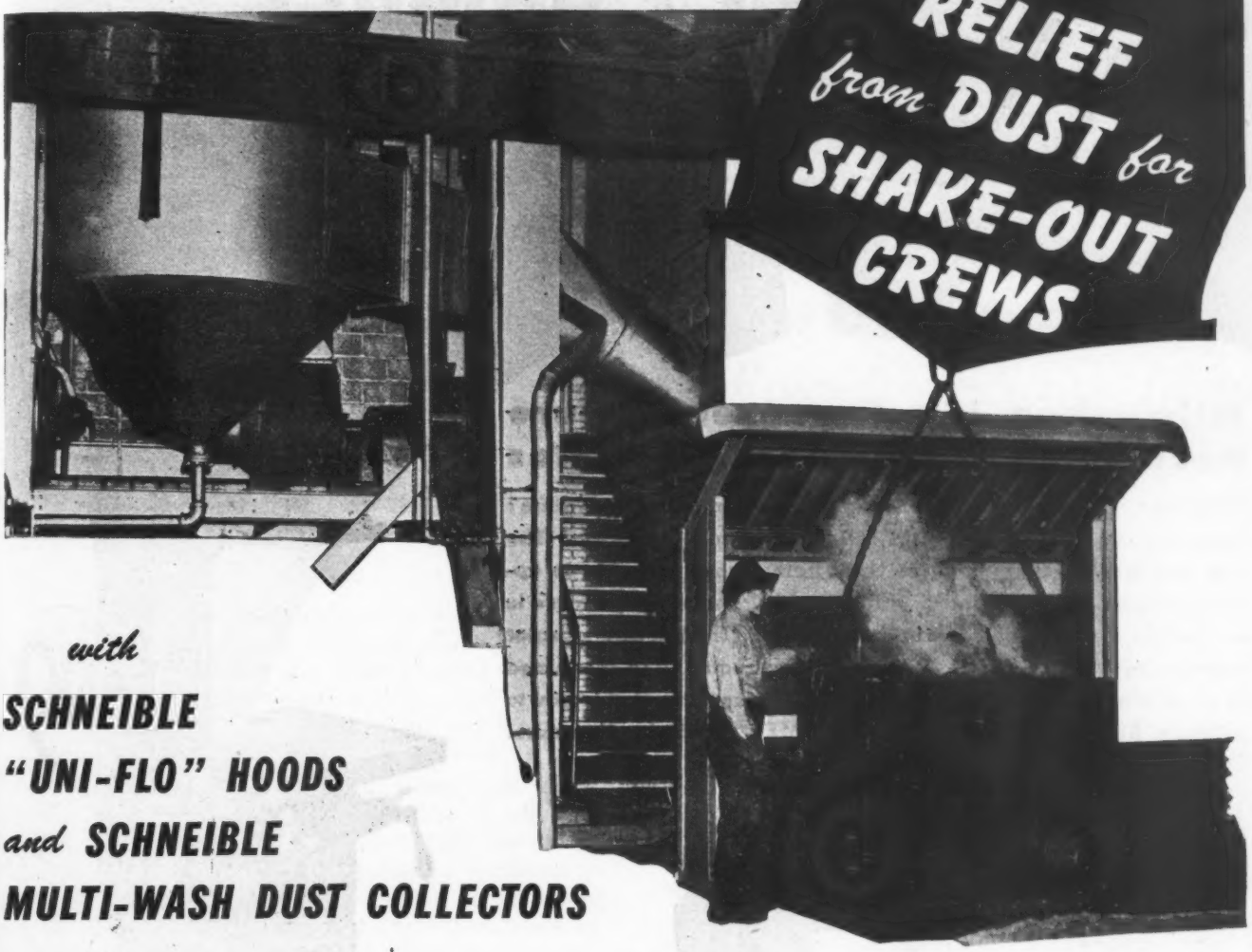

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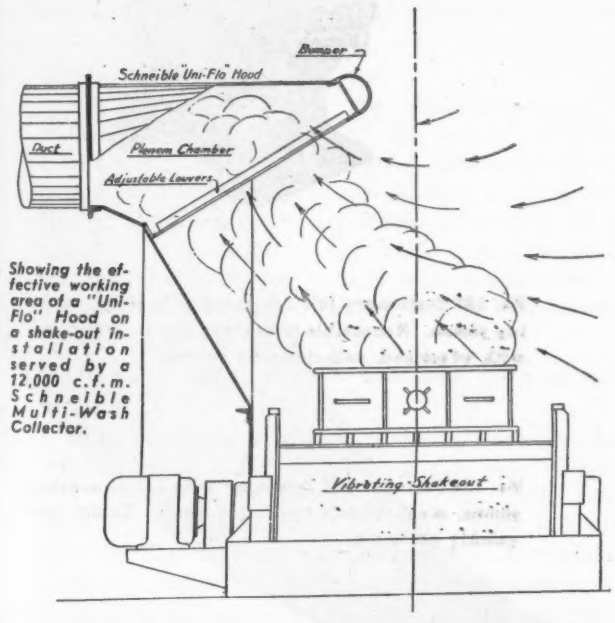

Showing the effective working area of a "Uni-Flo" Hood on a shake-out installation served by a 12,000 c.f.m. Schneible Multi-Wash Collector.

This combination, pictured above, has lifted the dust curse from the shake-outs of an ever-growing number of foundries; resulting in higher employee morale, increased working efficiency and lower operating costs.

The "Uni-Flo" Dust Hood is correctly designed for the continuous removal of dust-laden air from the working zone of a shake-out. Embodying a modern adaptation of the venturi principle of air control, its design combines in a simple, effective arrangement the known factors of air flow and air control to effect uniform velocity over the ventilated area with low resistance and minimum air volume.

Foundry shake-outs up to 12' x 20' have been successfully and economically ventilated by Schneible "Uni-Flo" Hoods, used with Multi-Wash Dust Collectors. Send for bulletins.

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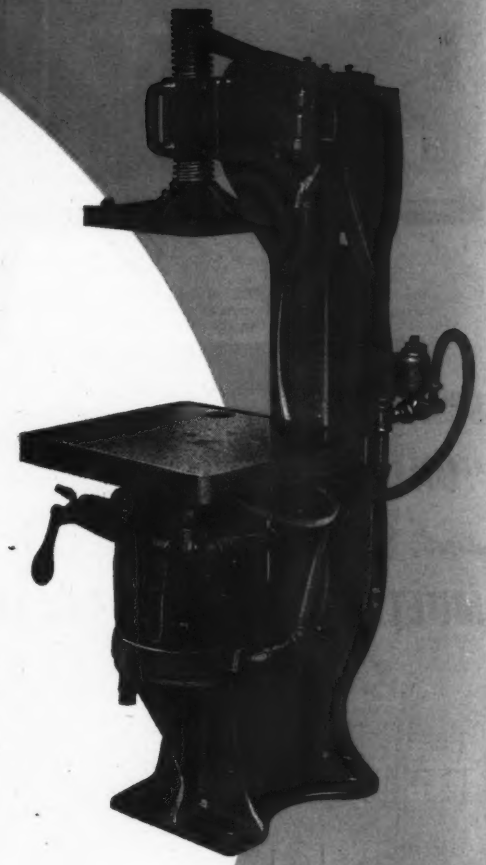

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Our first, full peacetime year brings with it tremendous decisions and responsibilities in adjusting the production of cast metals to meet the needs of all industry. There will be many problems—problems of production, processes, design, costs, specifications, and problems of manpower, as millions of returning servicemen seek permanent peacetime jobs to match their hopes, their ambitions, and their young ingenuity.

Yet 1946, as it marks the 50th Anniversary of A.F.A., may well mark also the beginning of the foundry industry's greatest opportunity. It is an opportunity for realizing its own strength and capabilities, and the vital role it plays in production of all manufactured products. And it is an opportunity to establish itself—almost, in fact, to re-establish itself—as a business offering untold rewards for imagination, individuality, and advancement.

Only by working together can these goals possibly be realized.

It has been said by men who should know that the membership of A.F.A. is far from at a peak. Today it is over 8,000. Two years ago it was 6,000. Four years ago it was 4,000. Two years hence it could easily be 10,000, if the foundry industry itself retains its present realization of the need to improve its practices, products, knowledge of castings, working conditions, and "humanics."

Never before have 8,000 men, all deeply concerned with the future of the foundry industry, been associated in a common cause. The vast experience, knowledge, and enthusiasm of this influential group cannot be discounted in calculating the potentialities of the foundry art and science.

The strength of A.F.A. lies—and it has always been so—in its over 500 Committee Members, its 30 Chapters, and its individual workers who constantly give to the industry as a whole the results of their experience and research, that they and their industry may advance together.

It is of such men that A.F.A. is composed. And it is in the minds of such men that this industry will advance its usefulness. No man could play a part in in this great work without achieving a fuller understanding of what cooperation really means.

No man could assume his duties as Secretary of such an organization without a deep sense of responsibility and obligation . . . the obligation to strive toward the standards set by men before him, and responsibility for further advancing an industry capable of producing such caliber of men.

Wm W Maloney

WM. W. MALONEY, *National Secretary*
American Foundrymen's Association

• ***Although it has been found that leaky castings of gun metal, valve bronze and hydraulic bronze may be made pressure tight by heat treatment under certain circumstances, it is believed that the practice of annealing bronze castings for the sole purpose of improving pressure tightness is a questionable expedient until such time as records may be obtained on the performance of sealed castings in service.***

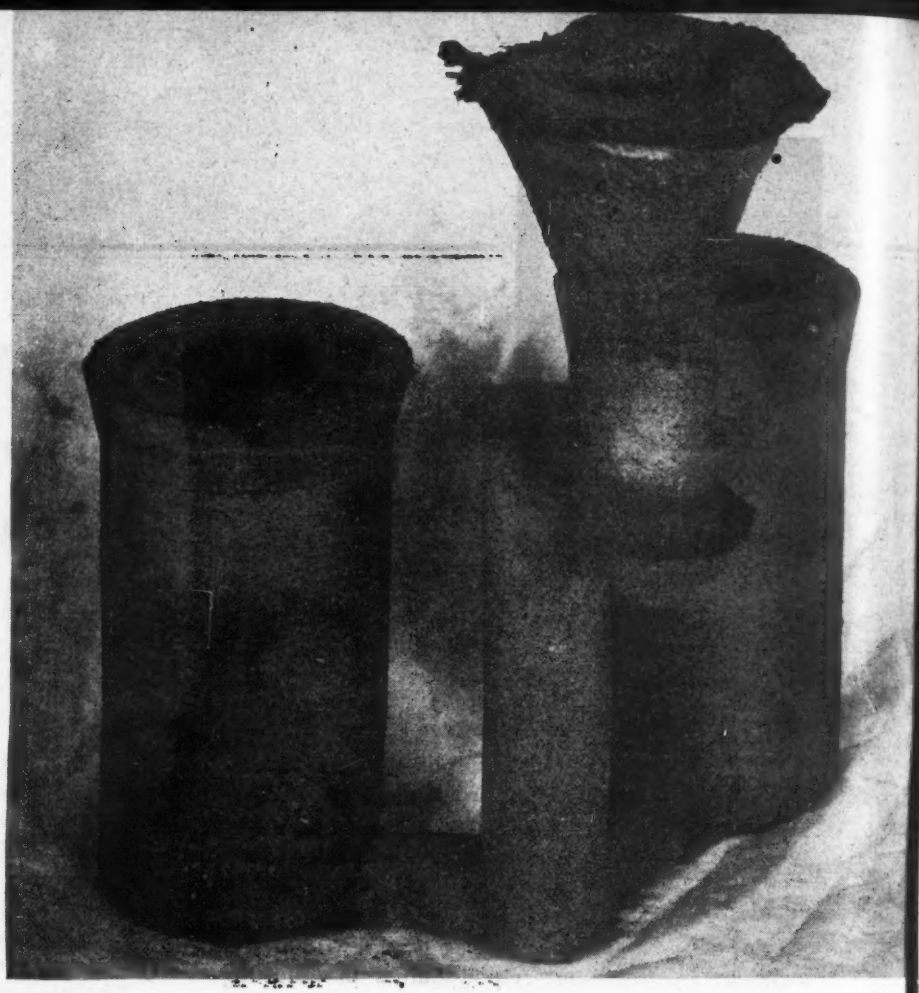

Fig. 1—Experimental bronze castings, bottom gated and cast at temperatures of 2280° F.

Sealing BRONZE PRESSURE CASTINGS *Through Heat Treatment*

By Lt. (j.g.) Fred L. Riddell, U.S.N.R.,
Division of Physical Metallurgy, Naval Research Laboratory,
Washington, D. C.

RECENTLY, the repairing of leaky castings by heat treatment has aroused considerable interest because it is considered by some foundrymen to be clean, rapid and fairly effective. The effects of such variables as proper temperature, time of treatment, degree of sealing and effect on mechanical properties have not been extensively reported.

The aim of the present investigation was to answer these questions for gun metal, valve bronze and hydraulic bronze by making porous castings and attempting to seal them by heat treatment under controlled conditions.

The mechanism of solidification of tin-bronze castings has been reported [1, 2] as one of the principal causes for porosity and leakage. In freezing, the bronzes with their long range of solidification pass through a mushy stage in which dendrites grow out into the melt and entrap pools of molten metal.

When this entrapped metal solidifies, the shrinkage is distributed throughout the casting wherever the interlocking dendrites prevent adequate feeding. Several investigators have explained the increase in pressure tightness following heat treatment as due to the closing of this microporosity.

In 1917, Elliott [3] reported that leaky bronze castings of complicated design could be made pressure tight by annealing for a short time at 1400° F. Nearly 75 per cent of the rejected castings were saved by this method, provided that the leakage was not too severe. Elliott found that the cored structure of the castings disappeared and that the elongation increased as a result of the heat treatment at 1400° F.

The observations of Elliott were in accord with the results of earlier investigators who found that tensile strength and ductility increased in bronzes held for 30 min. at 1300 to 1470° F.[6]

Jenkins,[4] in the investigation of a bronze of nominal composition 88 per cent copper, 8 per cent tin and

This paper, secured as part of the 1945 "Year-'Round Foundry Congress" and sponsored by Brass and Bronze Div., A.F.A., presents only the personal opinions of the author and in no way reflects the official attitude of the U. S. Navy.

4 per cent zinc, concluded that annealing in the range 1300 to 1455° F. gave increased pressure tightness with perceptible increase in ductility and a definite increase in all mechanical properties. Jenkins preferred annealing at this range of temperature to annealing at 1000° F. Annealing for one hour per inch of thickness at a temperature of 1400° F. was recommended.

More recently, Fleck and Bunch[5] heat treated gun metal castings at 1200 to 1400° F. to stop leakage. The sealing was reported to take place throughout the casting, and therefore was not removed in machining. The heat treatments were given for 2 hours per inch of thickness in a laboratory electric furnace.

Complete absorption of the delta constituent took place with a consequent decrease in hardness, but both the tensile strength and elongation increased slightly. A bronze containing 3.39 per cent of zinc softened much less than a bronze containing 2.39 per cent of zinc. Fleck and Bunch[5] warned that sealing would be successful only with good foundry practice.

Microshrinkage in Bronze Castings

Smith, Wiegand and Bolton[6] were doubtful about salvaging castings by heat treatment. They stated that microshrinkage was not removed by fusion, but merely blocked by oxide scale. The original defect and weakness were believed to remain.

It was also stated that valve bronze annealed at 1600° F. became partially fused and had low mechanical properties. Quenching from 1000° F. proved to be harmful to the mechanical properties of this bronze. Slow furnace cooling from the annealing temperature was recommended if the mechanical properties were to be unimpaired.

Horner and Mason,[7] in a more recent publication, reported that 90 per cent of a group of 150 rejected castings was saved by annealing for 2 hours at 1200° F. The authors emphasized that leakage from foundry defects such as tears, cracks, cold shuts and direct inclusions could not be remedied. To be benefited by heat treatment, the casting must not show more than a slight "weeping" when under pressure. The proportion of castings salvaged by heat treatment depends to a considerable extent upon the skill of the foundryman in properly classifying the failure before attempting the cure.

There is little agreement among the investigators as to the cause of improved pressure tightness of bronze pressure castings. Jenkins[4] stated that sealing was dependent upon an increase in volume of the matrix resulting from absorption of the dendritic structure. Others have claimed that the segregated constituents melt and flow into the regions of the shrinkage, thus blocking the interlocking channels of porosity.

Smith, Weigand and Bolton[6] believed that the formation of oxides of larger specific volume than the base metal was responsible for blocking the shrinkage cavities through which leakage occurred. Smith, Weigand and Bolton did not favor heat treatment as a means for increasing pressure tightness because the original weakness of the metal was believed to remain although the porosity might no longer be sufficiently open for leakage.

In the present investigation, 34 bushings of gun metal, valve bronze and hydraulic bronze were cast in a manner intended to produce leakage in a hydraulic pressure test. The pressure at which the bushings began to leak was recorded after various sealing experiments. The changes in microstructure and mechanical properties resulting from heat treatment were also investigated.

Experimental Procedure

(a) Foundry Procedure. The melting charges consisted of either Grade A copper, zinc, Straits tin and lead of high purity or selected scrap of known composition from the foundry of the Naval Research Laboratory (Table 1). The charges were melted in a 210-lb clay-graphite crucible in a lift coil induction furnace. The virgin copper or the selected scrap was melted under a charcoal cover in order to prevent excessive oxidation of the metal.

When the charge had become molten, two ounces of phosphor-copper (15 per cent phosphorus) per 100 lb. of metal served for deoxidation before making the additions of alloying elements. The tin, lead and zinc, with necessary compensation for melting losses, were then added in that order, and the addition of two or more ounces of phosphor-copper was made before casting. The bronze was intentionally cast at a high temperature, close to 2280° F., in order to increase the likelihood of porosity.

The molds were made from Albany green sand (Grade 00) containing from 7 to 8 per cent moisture. The molds were allowed to air dry at least 24 hr. before casting. The bushings were cast with two in each mold and were bottom gated (Fig. 1).

Thirteen gun metal, 14 valve bronze and 12 hydraulic bronze bushings were poured from the same temperature (2280° F.) with the same gating and risering practice. The standard cast tensile test coupon (Type 10A of ND Specification 46 M6g) was used for determining the mechanical properties of the three compositions.

(b) Machining of Bushings. The "skin effect" of each alloy was in-

Table 1

COMPOSITION OF MELTING CHARGES

Heat No.	Elements, per cent				
	Cu	Sn	Zn*	Pb	Ni
A1	87.78	8.95	3.17	0.10	—
A2	87.98	9.40	2.62	—	—
A3	88.40	9.10	2.36	0.14	—
A4	87.49	9.27	3.11	0.13	—
A5	88.02	8.32	2.85	0.08	0.78
B	87.36	4.80	2.00	0.95	4.89
C1	88.50	5.99	3.82	1.69	—
C2	88.41	5.28	3.83	2.48	—
C3	87.15	6.51	4.53	1.81	—
D1	85.65	5.11	3.76	5.84	—
D2	84.58	4.89	4.91	5.62	—
D3	84.76	5.18	4.82	5.24	—
E	88.05	6.09	2.81	—	3.05

*Zinc by difference.

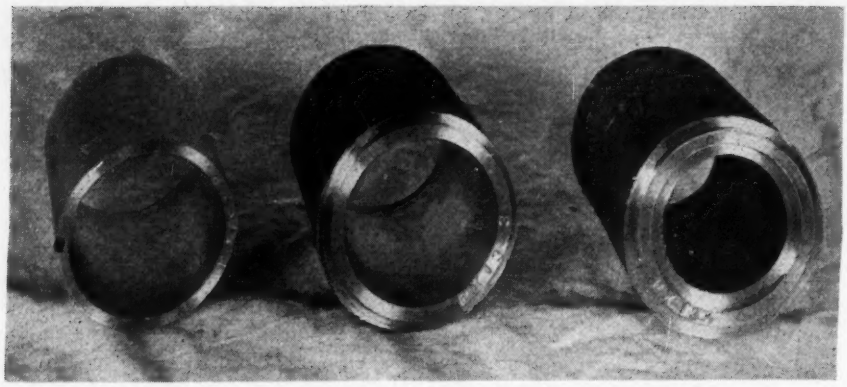

Fig. 2—Castings prepared for determining "skin effect" on pressure tightness, (left) inside and outside surfaces machined, (center) inside surface machined, (right) as-cast.

vestigated by (1) pressure testing in the as-cast condition, (2) with the inside surface machined, and (3) with the outside surface machined, approximately 1/16 in. being removed in each instance. A rim was machined on the ends of the bushings in order to fit the hydraulic tester.

The inside and outside diameters of the rim correspond to the diameters of the finished bushings. The inside diameter was 2-7/32 in., the outside diameter was 2-9/16 in., and the overall length of the bushings was 4-¼ in. (Fig. 2).

The highest test pressure for the bushings was 750 psi. This pressure was maintained for 5 min., and if no weeping occurred the bushings were considered pressure tight.

(c) Heat Treatment. The heat treatments were carried out in air, hydrogen, or oxygen-rich air atmospheres in a muffle furnace. The bushings with machined surfaces and the test bars with as-cast surfaces were placed in the furnace at room temperature, heated to the desired temperature, held for the desired length of time and then furnace cooled. Measurements of the diameters of the bushings were made following the heat treatments because of the possibility of dimensional changes.

In annealing the bushings in the hydrogen atmosphere, calcium chloride was used to absorb the water vapor and copper gauze at 842° F. (450° C.) was used to remove the oxygen in the hydrogen. In annealing the bushings in the oxygen-rich air, no attempt was made to remove the impurities in the oxygen.

Two manometers were placed in the system, one in the oxygen line, and one in the compressed air line in order to admit the respective gases at equal pressures. This resulted in a mixture of constant composition entering the box in the furnace. The gas entering and leaving the furnace was analyzed with an Orsat apparatus. The gas sample taken at the inlet contained 43.6 per cent oxygen and the sample taken at the outlet contained 39.0 per cent oxygen. The rate of flow was approximately 100 ml. per min.

(d) Micro-examination. The change in microstructure with heat treatment was investigated by heating samples of gun metal, valve bronze and hydraulic bronze at 1350° F. for 15 and 30 min., and at 1400° F. for one hour. The specimens were heated with the furnace, held at temperature and furnace cooled, then cut in half and polished on the freshly cut surface. They were etched with ammonium hydroxide and hydrogen peroxide followed by ferric chloride and alcohol. The photomicrographs were taken at 75 diameters.

Bushings failing at less than 25 lb. pressure were broken apart near the place of leakage. The inside surfaces of the shrinkage cracks were then examined at 75X magnification. Cross sections of bushing E-1 of Group 1 taken through the region of failure were projected on a ground glass screen for measurement of the widths of the shrinkage cracks and observation of the internal oxidation.

(e) Mechanical Tests. Unmachined coupons for tensile test bars were heat treated at the same time as the specimens for micro-examination and bushings for the sealing treatment. The tensile bars were of standard 0.505 in. diameter and

Table 2

CHANGES IN MECHANICAL PROPERTIES OF GUN METAL, VALVE BRONZE AND HYDRAULIC BRONZE WITH ANNEALING AT 1300 TO 1400° F.

Tensile Specimen	*Heat Treatment*	**Tensile Strength, psi.*	*Yield Strength, psi.*	*Elongation, per cent in 2 in.*	*Brinell Hardness, 500 kg. 30 sec.*
HYDRAULIC BRONZE					
D1	1	34,775	15,400	31.5	59
	2	29,400	15,100	18.0	52
	3	35,600	15,500	35.5	52
	4	34,100	15,300	29.5	50
	5	32,700	15,800	25.5	50
	6	34,225	15,425	28.5	51
VALVE BRONZE					
C2	1	36,600	18,100	30.55	60
	2	35,800	17,800	29.0	56
	3	36,600	18,200	36.5	56
	4	36,750	17,250	38.4	52
	5	35,850	17,000	31.7	51
	6	37,400	16,500	39.7	51
GUN METAL					
A3	1	44,000	21,250	34.5	73
	2	42,850	20,375	28.5	72
	3	46,650	22,150	46.0	72
	4	46,500	20,400	48.5	69
	5	44,400	19,000	52.5	57
	6	43,400	19,000	46.0	59

*Key to Heat Treatment—1. As Cast. 2. 1350° F. for 15 min. in air. 3. 1350° F. for 30 min. in air. 4. 1400° F. for 1 hr. in air. 5. 1400° F. for 3 hr. in H_2. 6. 1400° F. for 2 hr. in O_2 atmosphere.

Table 3

RELATIVE PRODUCTION OF POROUS CASTINGS FROM THREE ALLOYS

Alloy	*Bushings Cast*	*Leakers (Machined I.D. and O.D.)*	*Porous Castings, per cent*
Gun metal	13	12	92.5
Valve Bronze	14	11	78.5
Hydraulic Bronze	12	8	66.7

2-in. gauge length. The elongation, yield strength at 0.5 per cent offset, tensile strength and Brinell hardness are given in Table 2.

(a) Foundry Practice. To produce castings with the type of defect which would permit sealing by heat treatment, the foundry practice was chosen so as to give defective bushings. For the present purposes, perfect castings as well as those with gross defects were discarded. The high pouring temperature, bottom gating and 8 per cent of moisture in the molding sand generally gave the desired degree of porosity. The relative difficulty in making porous castings of the three alloys is shown in Table 3.

It is apparent that hydraulic bronze has the least tendency to leakage. Although 31 leaky castings were produced, less than half of these contained the "weeping type" of leakage suitable for sealing by heat treatment. Three nickel-tin bronze cylinders were also included in the present investigation in order to test the possibility of sealing this composition of bronze.

(b) Effects of Heat Treatment on Pressure Tightness. The available bushings were divided into two groups for testing. The first group, consisting of gun metal and the nickel-tin bronzes, was machined inside and out before testing.

The second group, made up of gun metal, valve bronze and hydraulic bronze, was tested first as cast in order to investigate the influence of the oxidized skin before machining the inside and then the outside diameters. The subdivision of the bushings of each group on a basis of composition was intended to reveal possible differences in the tendency to seal by heat treatment.

In Table 4 the bushings of Group 1 show that partial sealing by heat treatment has been confined largely to the outside layers of the bushings. Although the average pressure tightness has increased more than 100 per cent by annealing at 1350° F. and 1400° F., this means little from a practical point of view because a light polishing with emery cloth was sufficient to remove the thin layer of pressure-resistant oxide.

The reason for the average pressure of column 4, (Table 4) being below the average pressure of the machined bushings of column 1 is explained by the tendency of the machine tools used in preparing the specimens to drag metal into the openings of shrinkage cavities.

This mechanical obstruction was removed by the oxidation in treatments 2 and 3. Heat treatment in dried H_2 caused a further drop in pressure tightness because oxides occurring in shrinkage cavities were reduced to pure metals having considerably less volume than the oxides.

Reheating in an oxygen-enriched atmosphere for 3 hr. did not repair the damage done by hydrogen treatment. However, the longer time of treatment and higher concentration of oxygen in treatment 6 gave greater penetration, as shown by moderate decline in average pressure when the oxide scale had been removed (Table 4).

The bronzes of Table 5, in general, had a dense, pressure-tight skin which gave a fair degree of pressure tightness in the as-cast condition. The following variations in treatments gave results somewhat different from those in Table 4. Longer time at temperature gave higher pressure tightness. Annealing for 3 hr. at 1400° F. appeared to give no better results than annealing at 1300° F. for the same length of time.

Distortion of Thin Sections

In fact, annealing at the higher temperature may have been dangerous because of distortion of thin sections. The bushings annealed at 1400° F. had variations of diameter of approximately 0.005 in. The removal of the oxide scale did not result in any appreciable loss in pressure tightness following the longer annealings at 1300° F.

The hydrogen treatment also did not prove so detrimental. However, none of these results can be accepted as favorable, because the bronze is still mechanically very weak. The regions where leakage had previously taken place still possessed porosity easily visible at 75X magnification. The fracture of the porous bronze had a reddish discoloration.

The hardness remained lower in regions of leakage than in surround-

Table 4

HIGHEST PRESSURES FOR NO LEAKING OF BRONZE BUSHINGS
(PRESSURE HELD 5 MIN.)

Group 1.

	Pressures, psi.						
	1	2	3	4**	5	6	7**
Bushing Number	*As Machined*	*1350° F., 15 min.*	*1400° F., 1 hr.*	*Oxygen Scale Removed*	*1300° F., Hydrogen Atmosphere, 3 hr.*	*1200° F., Oxygen Atmosphere, 3 hr.*	*Oxygen Scale Removed*
A1-1	50	170	100	0	0	5	10
A1-2	100	200	300	25	5	*	25
A1-3	120	400	200	25	10	*	50
A1-4	300	400	600	40	5	100	75
A1-5	25	150	300	35	20	100	75
B1	300	750	750	150	25	400	350
B2	250	400	750	50	25	200	200
E-1	50	125	100	25	†	—	—
A5-1	100	300	320	25	10	25	25
Avge. Pressure	144	322	380	42	12	138	101

*Not heat treated further.
**Oxide scale removed by polishing with emery paper.
†Sectioned for photomicrographs.

ing regions of the surface which were pressure tight. At many places the difference in hardness was twenty to thirty Brinell (converted from Rockwell E), and with Brinell hardness of 60-70 numbers this means that a major percentage of hardness has been lost through the defectiveness of the material. Low hardness of bronze is an indication of unsoundness.

As further indication that sealing is a process of oxidation, two bushings, as-cast, were annealed in hydrogen without previous heat treatment in an air or oxygen-rich atmosphere. The pressure tightness was found to be the same or less when retested after this treatment.

Changes in Microstructure

(c) Microstructure. The disappearance of the cored structure and the delta constituent on annealing for various periods of time are the most significant changes in the microstructure. The grain size was unchanged by the heat treatments. In general, the delta constituent disappeared after one-quarter hour and the dendrites after one hour at temperature (plus slow heating and cooling), as shown in Fig. 3.

There was little difference in the appearance of the structure of gun metal, valve bronze, and hydraulic bronze after one hour of annealing. The dendrites and the delta phase had been dissolved in the matrix of alpha solid solution. The black areas in the gun metal are porosity and in the hydraulic bronze both porosity and lead particles.

The microstructure of a bronze which leaks under pressure is the same as that of any other bronze except for the presence of porosity. A photomicrograph of specimen E-1 of Group 1 (Table 4) which leaked at a pressure of 25 lb. showed that the microshrinkage cracks are from 0.01 to 0.05 in. wide (Fig. 4).

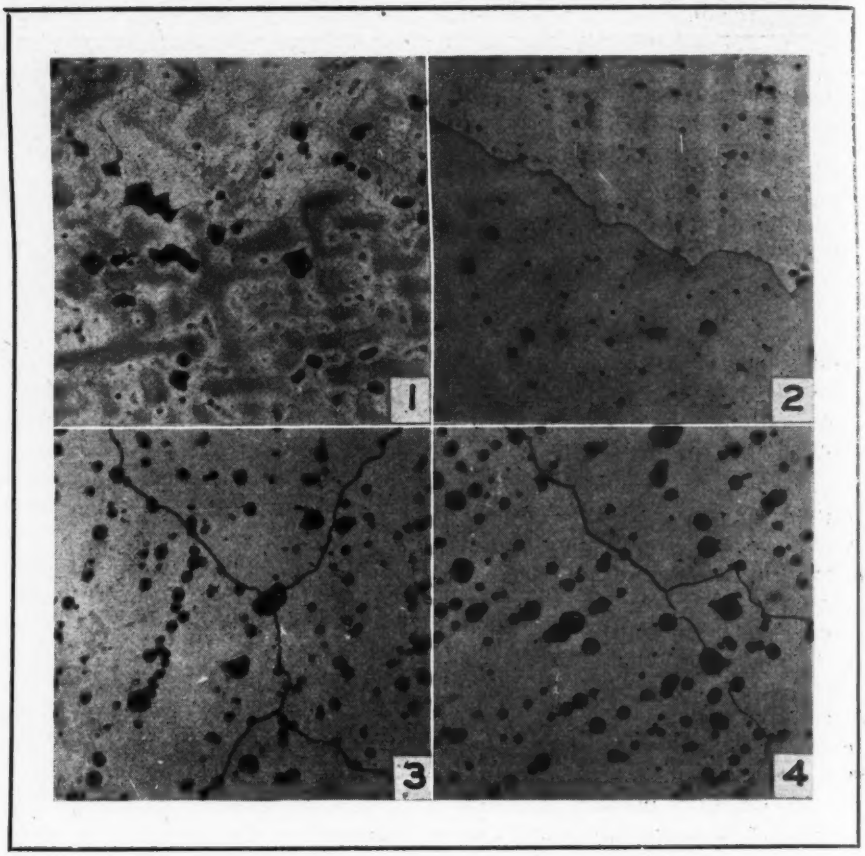

Fig. 3—Change of microstructure of composition "G" with heat treatment. (1) As-cast. (2) Heat treatment at 1350° F. for 15 min. (3) Heat treatment at 1350° F. for 30 min. (4) Heat treatment at 1400° F. for one hr. Magnification, 75X. Etchant, NH_4OH-H_2O_2 and alcoholic solution of $FeCl_3$. Specimens heated slowly to temperature and cooled slowly in furnace.

Since the sample was not etched, it is possible to identify the fringe along the edges of the cracks as an oxide layer. In this bushing the cracks were too wide for the oxide to fill the gap, and sealing by heat treatment was not effective.

(d) Mechanical Properties. The mechanical properties of sound tensile bars were little changed by the heat treatment, with the exception of the decrease in hardness which coincides with the disappearance of the delta phase after about 15 min. of annealing at 1350 to 1400° F. The hardness of gun metal, valve bronze and hydraulic bronze specimens generally decreased by 10 to 15 points Brinell (500-kg. load).

Gun metal specimens increased in tensile strength from 44,000 to 46,500 psi., and in elongation from 34.5 to 46.0 per cent after being annealed in air for one hour at 1400° F. Additional annealing of gun metal specimens produced slight decreases in tensile strength and yield strength. Annealing sound tensile bars of the three bronzes in hydrogen and oxy-

Table 5

HIGHEST PRESSURE FOR NO LEAKING OF GUN METAL, VALVE BRONZE AND HYDRAULIC BRONZE BUSHINGS (PRESSURE HELD 5 MIN.)

Group 2.

	Pressures, psi.							
	1	2	3	4	5	6	7	8
Bushing Number	*As Cast*	*Machined, Inside Diam.*	*Machined, Outside Diam.*	*1200° F., 3 hr.*	*1300° F., 3 hr.*	*1400° F., 3 hr.*	*Oxygen Scale Removed*	*1200° F., Hydrogen Atmosphere*
A2-1	50	50	300	620	700	700	700	—
A2-2	75	75	75	180	240	300	100	75
A2-3	125	750	300	700	700	750	750	450
C1-1	700	750	25	50	200	100	250	100
C1-2	750	150	25	50	200	200	220	120
C1-4	750	750	25	100	200	200	190	—
D1-1	750	750	100	750	750	750	750	300
D1-6	750	750	100	750	750	750	750	100
Average Pressure	494	503	144	400	468	469	464	277

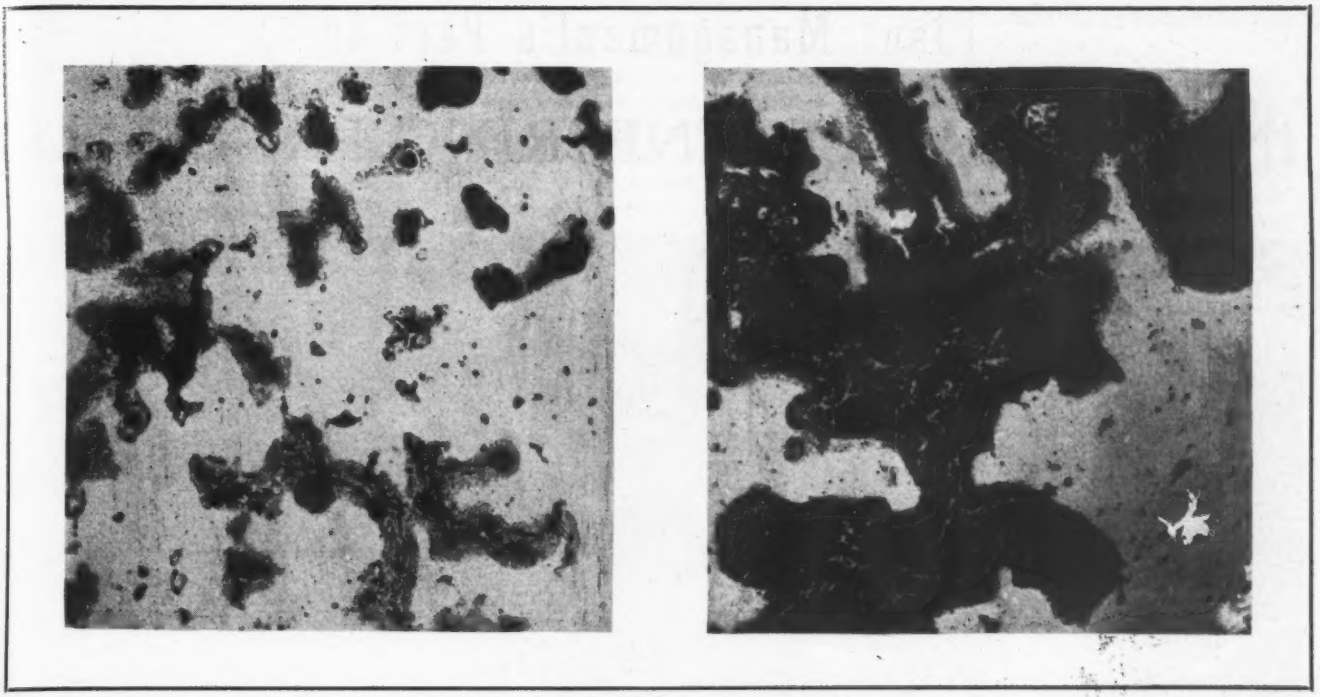

Fig. 4—Photomicrographs of bronze casting (Specimen E-1, Group 1, Table 4) showing microshrinkage. Heat treatment—1 hr. in air at 1400° F. Cross-sectioned and polished. Unetched. 75X. (From two different locations of same specimen.)

gen produced little effect on the mechanical properties (Table 2). Valve bronze and hydraulic bronze specimens were much less affected by the annealing treatment than was the gun metal.

Conclusions

The pressure tightness of leaky bushings of gun metal, valve bronze and hydraulic bronze was improved when they were annealed for 3 hr. at 1200 to 1300° F. in an air or oxygen-rich air atmosphere. No sealing whatever took place in a hydrogen atmosphere.

When bushings previously improved in pressure tightness by annealing in the oxygen-rich air were re-annealed in hydrogen, the pressure tightness decreased by 25 to 50 per cent. Removing the outer layer of oxide scale after sealing in air did not cause appreciable loss in pressure tightness provided that the bushings were annealed for 3 hr. at the necessary temperature (Group 2, Table 5).

The bronze specimens used in this investigation were sealed by the formation of oxides of larger specific volume than the base metal. The oxide layer on the inside of fine shrinkage cracks tended to close the openings provided that the cracks were of sufficient fineness. The tendency for leakage of unsound bronze may become serious after several years of service, and the wear resistance of moving parts is certainly lower with unsound metal.

The short-time pressure test at room temperature is not equivalent to conditions of service, which include the factors of corrosion, abrasion, application of stress, wear and changes in temperature. It is believed that the annealing of leaky bronze castings to improve pressure tightness should be exercised with care until such time as information may be obtained over a period of years on the performance of sealed castings in various services.

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Written discussion of this paper is solicited for publication in future issues of "American Foundryman" and/or bound volume of "Transactions." Discussions should be sent to Secretary, American Foundrymen's Association, 222 West Adams St., Chicago 6.

Raybestos Receives Award From Army-Navy Officials

FOR meritorious service on the production front, The Manhattan Rubber Mfg. Div., Raybestos-Manhattan, Inc., Passaic, N. J., has been rewarded, for the third time, with the Army-Navy "E" award.

The company was presented the original award in October, 1943, at which time the company was celebrating its 50th anniversary.

Plant Management's Part In
INDUSTRIAL ENGINEERING PROGRAMS

Complete understanding is necessary for the success of industrial programs.

THE borderline band between profit and loss is but one cent wide. The boundary between success and failure in business is, perhaps, no wider. Inevitably, the success of a company is reflected in its ability to make a profit.

There is no royal road to insure this objective, but in the *intelligent* use of industrial engineering, many large companies and many small companies have found the way to produce at 5, 10, or 15 per cent less cost. However, the cold fact remains that many other firms which turn to engineering management fail to make the program click.

What is Industrial Engineering? The scope of industrial engineering is broad and varied. There is no universally accepted definition for it. It means, to some, time study engineering, and to others, wage incentives, standards, layout, methods, cost control, production planning, or even the whole field of scientific management. One defines it best by listing the work or functions which it is desired to embrace and then establishing a staff to carry on the designated work.

Just as the military has staff and line departments, so too should industry. In the foundry the *line* was from president on down to operating manager, superintendent, general foreman, foreman, and gang boss; they aid in holding the line.

The staff departments, when set up as such, generally are the metallurgical or the laboratory, the personnel, the production control, the plant engineering, and sometimes the industrial engineering.

Old-line foundry management did not believe in having staff functions separated from line control. The superintendent ran everything. The head melter did what metallurgy the shop required. The foundry foreman ran the scheduling from an envelope in his hip pocket.

He or his assistant foreman did their own hiring and firing. If they chose to have piece rates, they set them from experience. The master mechanic did whatever engineering or construction jobs there were to be done.

With the growth of multi-plant

By Wally E. George, Account Manager,

Booz, Allen & Hamilton,

Chicago

● ***Whole-hearted cooperation between operating organization and staff technical specialists is necessary for the success of any industrial engineering program. The many new and complicating factors confronting the postwar foundry require the adoption of a planned program and intelligent use of the engineering staff.***

companies came staff management. World War I and the booming Twenties saw many foundries setting up staff departments. Some succeeded—many failed. There were frequent skirmishes between staff and line men for authority. The staff man was an outsider and when, as too often happened, his work was passively resisted by the old timers' clique, it fell flatter than a pancake.

Industry Needs Engineering Control. Management is no longer the simple matter of making and selling castings at 20 per cent over cost that it once was. New laws have complicated matters. Labor legislation, the advent of the mass union organizations, the rising tide of taxes of all varieties, the specifications for alloyed metals, the demand for x-ray and magnetic particle examinations for defects, and the mechanization of the industry are but a few reasons why a plant or company of any size today has been forced to come to staff departments manned by technical specialists.

Sheer tragedy lies in a foundry's failure to make intelligent use of the engineering technicians it employs. C. T. Kettering has likened the hiring of a research man into an old-line organization to the tossing of Daniel into a den of lions. The Lord saved Daniel, but most of the staff men in foundries, unfortunately, are not possessed of Daniel's religious fervor or indispensability. To make a bad pun, they are devoured by the *lines* before they get started.

Staff and Line Cooperation

This is all very expensive on the industry. There is so much that the technical man can do. There is so much to be done to keep a foundry in a competitive position. A way must be found to get the staff on a proper footing so that the friendly cooperation of the line will assure success of the whole profit control program.

How Much Industrial Engineering for the Foundry? The foundry program of industrial engineering should be threefold:

1. There is the program of *preparation.* The equipment, the layout, and the methods all must be studied. Greater production per man hour with less physical effort and in better surroundings must be achieved for every operation.

Engineering analyses when combined with the practical experience of the man running the operations can do wonders, whether the work be of a production or jobbing type.

2. There is the *standards* program. Standards call for standardization of every operation. Standard practice data for speeds, feeds, number of jolts, temperatures, sand mixtures, baking times, gating and risering, air pressures, flask sizes, use of chills, finish and inspection requirements are but a few of the items that standardization can help.

Operating Standards

If the foundry management does not provide these operating standards for its line supervisors, it can never hope to produce uniform quality or to keep defective work under control. If one way is better than another, management should see that every foreman knows and teaches that method.

After the right layout and method are devised, motion study comes in to further simplify the work or human effort. The one best way must be set as the standard, and the proper time for it must be established either by time study or by time-studied standard data and figures.

Wage incentives are needed, because a good man working hard can exceed a fair standard by 20 to 30 per cent and deserves a 20 to 30 per cent reward for such output.

Cost standards are another part of the standards program. Good management should be able to tell its supervisors the proper cost for any operation. If it cannot do so, it cannot fairly tell when a foreman is making a real success of his job.

Cost standards should be established to provide a comparison for dollar spent for labor, material, and expense under all conditions and for all classes of work.

3. There is the program of *cost control.* Good standards, adequate incentive plans, and proper cost control budgets provide management with tools for knowing where they are going profit-wise. Labor needs can be forecast based on tomorrow's schedule.

Actual labor used can be compared to standard for yesterday's performance and for last week's. Labor costs and all other elements of expense can be compared weekly or monthly as preferred.

The line supervisor must be the manager of his department. He spends money every time he signs a labor ticket or a material requisition. He must know what he spends and how this total stacks up against what he should be spending. Unless management can tell him this, they cannot expect him to contribute intelligently to the profits program.

Every management should be able to estimate its cost before it takes an order. The easiest and quickest way to go broke is to sell *at* or *under* the competitor's price without knowing if the price is right or if one can produce as economically as can his competitior. The scores of foundries which go broke every year attest to the danger of this sales-pricing method.

Cost Accounting System

Accurate estimating of expected costs before a bid or price is ever made is the answer. The sound foundry estimate should come as a combination of careful planning for the equipment and the operations, coupled with the determination of the probable output per man hour, sound prediction of scrap losses, plus proper application of metal costs and overheads for departments and for plant-wide expense.

The industrial engineer should steer every estimate and compile it, but it must meet with the approval of the planning group and of the superintendent.

Good profit control demands an accounting system which makes profit figures readily available during a run as well as at its conclusion. The industrial engineer should have access to all actual cost data and be able to turn out comparative cost figures that parallel his estimate at any time the management, the sales

Written discussions of this paper are solicited for publication in future issues of "American Foundryman" and/or bound volume of "Transaction." Discussions should be sent to Secretary, A.F.A., 222 West Adams St., Chicago 6.

This paper was secured as part of the 1945 "Year-'Round Foundry Congress" and is sponsored by the Job Evaluation and Time Study Committee of A.F.A.

department, or works manager require information as to the status of a job or order.

A foundry seldom makes money by accident. Eternal vigilance and constant cost comparisons with the standards or the estimates are powerful elements of profit control.

How to Correlate Staff and Line Operations. To attempt to jam a time study or wage incentive program down a foundry foreman's throat is futile. Passive resistance on his part is such a strong and yet so subtle a weapon that he can render the best of engineering programs valueless.

Unless the foreman can understand the program and can appreciate its need, one should either give up the program or change the foreman. This is harsh advice but is seriously given and with an idea to economy of time and expense.

Definitions help. Delineation of authority between staff and foreman in a single-plant company, or between general office staff and the works managers in a multi-plant company is highly essential. The foundry manager has a right to feel that he is running every man in his plant and that all plant staff men are his own staff.

He is, therefore, vitally concerned with programs, plans, and installations on which his staff work. He wants no cut and dried incentive plans or control media foisted on his organization until he can review and test them in the light of what is sound or beneficial for his men and his foundry's operations.

Planning the Program

Best way, then, to begin any staff program is to plan it out all very carefully with the men who must help make it work. If in a single-plant company, the operating head, the plant manager, the superintendent, the controller, the personnel man, and the industrial engineer or staff head all should participate.

If in a multi-plant company, the operating vice-president, the controller, the personnel director, the chief industrial engineer, and the works managers of all plants concerned should take part.

Plans under consideration should be considered and tested from numerous angles. How would they affect the workers and the foreman; what new records would be required; what of production; what about costs of installation and operation; how about the profit angle?

Sound planning of this nature takes time. Any foundry can improve its employee relations if it studies and analyzes its whole wage administration program with an eye to coming abreast of the times.

Necessary, or at least extremely helpful, are frank and open statements of policy, the preparation of an employees' manual, the adoption of an evaluated wage schedule, the issuance of a clear-cut statement or explanation of any new or old incentive plan, and the undertaking of broad educational or training plans to acquaint both supervision and workers alike with the objectives of management.

This sounds like a big mouthful, but the preparation and explanation of such a broad program will force management to correct inconsistencies in operations and policies, and will return healthy dividends. Best of all, the work bridges the heretofore uncrossable gulf between line and staff, sets them to pursuing a common goal, with a mutual respect each for the other.

From understanding comes cooperation and cooperation points the way to success.

PEARL HARBOR
Foundrymen Pay Tribute to A.F.A.

MEMBERS of the Non-ferrous Division might possibly recall the paper presented before the 1938 convention written by T. C. Bunch and H. Fleck, then foundry superintendent (master molder) and junior metallurgist, respectively, at the U. S. Navy Yard, Pearl Harbor, Hawaii. This paper can be found in the A.F.A. TRANSACTIONS, Volume 46 (1938) and is entitled "Heat Treating Zinc Bronze Pressure Castings to Close Leakage." When the July, 1945, issue of *The Foundry* appeared with an account of the Pearl Harbor foundry work, a letter was written to Mr. Bunch from the A.F.A. office, and in the reply Mr. Bunch refers to having served his apprenticeship under J. C. Pendleton, master molder, Norfolk Navy Yard, and Stanley W. Brinson, who succeeded Mr. Pendleton as master molder. Mr. Pendleton, one of the first directors of our Chesapeake chapter, is now head of the foundry, Newport News Shipbuilding Co., Newport News, Va. Mr. Brinson is master molder at the Norfolk Navy Yard, Norfolk, Va. Mr. Brinson is an A.F.A. Honorary Life Member and our members will remember him for his valuable papers of foundry work.

T. C. Bunch

Praises Papers

Mr. Bunch in his letter pays high tribute to the A.F.A. for its influence in furthering war work, as follows: "I would like to express my appreciation for the help and instruction received through the various papers of the Association. There is no measuring stick applicable, but we all know that the war effort has been aided immeasurably and that the quality of foundry products has been greatly improved by dissemination of information contained in the various papers presented. We have developed quite a few changes in orthodox practices out here and hope that we may have the necessary time to prepare a paper in the not too distant future."

J. C. Pendleton

S. W. Brinson

Industrial Status of
PRECISION CASTINGS

By Capt. W. A. Morey,
Chicago Ordnance District,
Chicago

● ***Sixteenth Century art castings and Twentieth Century gun parts produced by the same basic process. Developments in the precision casting process have made possible volume production of small, intricate parts allowing almost unlimited choice of materials.***

FOR some reason it seems that every time a new process is discovered its advantages and possible applications are greatly exaggerated until it is fairly well along in development. Precision casting is no exception to this rule.

Precision casting or investment casting, according to some people, is a new process which will, in the near future, undoubtedly make all foundries and machine shops obsolete. This is, of course, basically untrue since precision casting at the moment applies only to a relatively limited field and is most emphatically not a cure-all.

Some of the confusion apparently has arisen from what appears to be rather loose use of the words "investment casting" and "precision casting." To get a little closer to bedrock, the author proposes, at least as a starting point, some definition of just what these terms mean.

Investment Casting

The word "investment," in addition to involving those mysterious and profound transactions which will undoubtedly make our fortunes, also means covering or enrobing, and it is the custom of the dentist or jeweler to refer to a one-piece ceramic mold as an investment, since it completely covers the pattern and has no line of separation, i.e., no cope and drag.

Investment casting, therefore, should be defined as a metal-casting process employing an expendable pattern in conjunction with an unparted or one-piece mold. Precision casting is a refinement of investment casting wherein through certain techniques the resultant metal casting is held to tolerances not exceed-

Fig. 1—Example of Sixteenth Century casting by the investment molding process. *(Courtesy Art Institute, Chicago)*

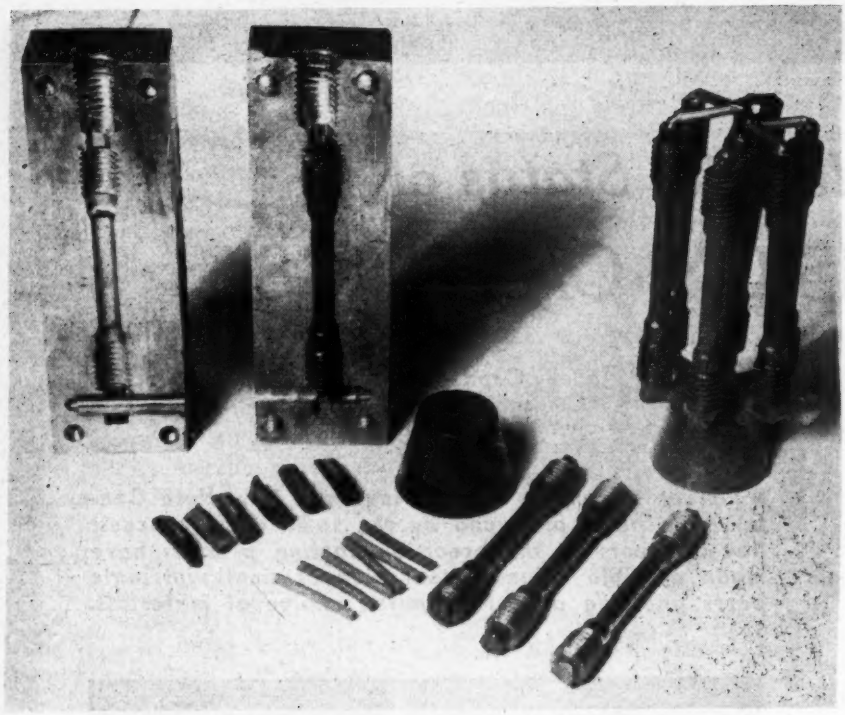


Fig. 2—Molding (left) and assembly (right) of the expendable pattern.

ing plus or minus five thousandths of an inch and having a surface finish at least "CF" or better. These definitions are admittedly open to considerable criticism and improvement, but they help to clear up some of the existing confusion.

Investment casting and, to a certain extent, precision casting, is one of the very old brand-new arts. Actually, Cellini in the Italian Renaissance period used investment casting to produce several of his art objects, such as "Perseus with the head of Medusa" (Fig 1). Since it was used for statuary, it must have had a certain amount of precision, although probably not as close as we would demand today.

It is doubtful that the process ever completely disappeared, and it is certain that for some time past it has been employed by both dentists and jewelers, particularly the former, to form low-melting-point metals into precise but irregular shapes.

Prior to the war, certain of the dental technicians had been working with the casting of non-ferrous alloys, such as Co-Cr-Mo alloy, and had been able to cast this material successfully into precision shapes required in dentistry.

Since Co-Cr-Mo alloy has a melting point of slightly over 2400° F., it was obvious that the process was getting out of the lower-melting-point phase and approaching steel-casting temperatures. Although the process itself will be covered in greater detail later in the paper, a brief review of the general procedure in making investment castings is in order at this point.

Forming the Pattern

The first step is to accurately form the pattern of some material, such as wax, plastic or low-melting-point alloy, which can be melted or burned completely out of the mold and having no residue (Fig. 2). All three types of patterns are in use today, wax being the most popular at the moment.

These patterns are then attached to sprues, runners, and a button or entrance gate and coated by dipping or spraying with a primary investment (Fig. 3), which normally consists of a finely divided sand with a binder and other materials. Other processes do not employ a primary investment, as will be seen later.

When the primary investment has set, the pattern is attached with the entrance gate downward to a metal or rubber plate, and a container, usually of stainless steel, telescoped over the pattern. An investment material is then poured into the container (Fig. 4) and thoroughly tamped to settle the investment material closely around the pattern.

This investment material consists of a ceramic aggregate, usually sand and/or grog, together with a binder having good refractory characteristics, such as tetraethyl orthosilicate, which upon ignition forms a network of SiO_2 binding the grains together. After tamping this material is allowed to dry for varying periods of time, depending upon the technique employed, and is then placed in an oven or steam bath which melts out or vaporizes the pattern.

Heating the Mold

Since the next step is to heat the mold to temperatures in excess of a 1000° F., the product will be a ceramic mold without any parting line and having a perfectly formed cavity which was formerly occupied by the expendable pattern. The molds are placed in a casting machine while hot and molten metal of the proper temperature is forced into the cavity under some type of pressure, this pressure being generated by air (Fig. 5), by centrifugal force or, in the case of ordinary investment casting, by static head only.

The metal is allowed to solidify under pressure, permitted to cool and subsequently the ceramic mold is broken away from the casting. The castings are then cut from the sprues, visually inspected, sand blasted, cleaned, x-rayed, etc. If properly cast, substantially no machining other than removal of the sprue is necessary.

The impetus given to this process by the war has been enormous. It is believed that the Air Corps was the first of the Armed Services to become interested in the process due to the urgent need for large quantities of turbosupercharger blades, which must be made of heat-resistant alloys difficult if not impossible to machine.

Much credit is due to companies which worked on this process and solved its problems over the trying years we have seen. Suffice it to say, however, that the production is going forward on a large scale and is meeting our needs at costs which immediately prior to the war were considered practically impossible.

The Ordnance Department having somewhat similar problems was also greatly interested in precision casting, but its requirements natur-

ally differed from those of the Air Corps. Ordnance was interested primarily in the casting of many different intricate parts from SAE and NE alloys, which proved to be the most difficult of all to cast.

The non-ferrous alloys appeared to be non-corrosive to the molds employed and fairly easy to cast, but the SAE steels, including the high- and low-carbon steels are highly corrosive and very difficult to handle. However, by careful control of the materials, times, temperatures and pressures employed, Ordnance was able to obtain from various suppliers certain steel parts for testing.

At first the test results were erratic because of lack of adequate control in the casting process, but as these problems were more clearly understood control improved and with it the consistency of results.

A little over a year ago, it was felt that the process had progressed far enough to warrant comprehensive tests on certain small, intricate parts needed by Ordnance. At that time it appeared that the vendors were able, within reason, to produce castings of 4140 and other similar alloys on a production basis to tolerances of the order of three thousandths of an inch and having an "f" finish.

Although there had been previous test work conducted on various parts for cannon breeches, the carbine was selected for test purposes since it was perhaps better adapted to precision casting and made in quantities sufficiently large to give an overall picture. The results of these tests were quite surprising.

Most of us are familiar with the carbine and realize that many of the parts are quite highly stressed. Certain of the parts in the carbine, such as the extractor, hammer, sear and trigger, were selected for test, and approximately 5,000 sets of parts were cast and assembled into complete weapons. Approximately 3,700 carbines were issued to troops for field trial. After firing about a quarter of a million rounds in these carbines, total damages occurring were three broken extractors.

Testing Carbine Parts

Some difficulty was experienced in keeping track of the test results, so these guns were collected and shipped to various arsenals and plants for further test. Here again the test results proved to be excellent and, in many cases, exceeded the life expectancy of machined parts.

One of the armories testing these carbines reported that they had fired 12,000 rounds in one, 6,000 in two others and 4,000 in another without any malfunctions, cracks, or breakages occurring in any of the cast parts. The only difficulties encountered were that certain of the parts appeared to be susceptible to premature failure at temperatures of — 40° F., and this was probably due to improper chemical control during the casting process.

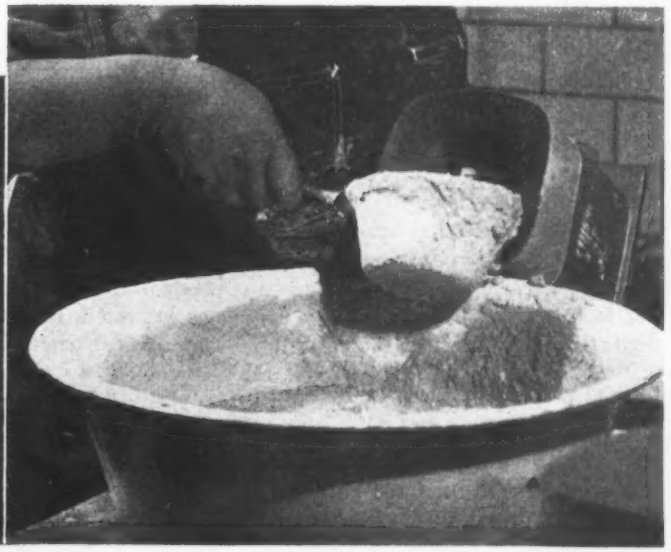
One of the firms manufacturing carbines fired 65 of them, the quantities varying from 6,000 to 34,000 rounds. Since the extractors are the most critical and highly stressed parts, most of the test concentrated on these. All triggers, hammers, and sears functioned correctly and showed only normal wear after firing 17,000 to 34,000 rounds each, and no failure is expected in the remainder of the test firing.

Fig. 5—Air pressure casting machine.

In the case of extractors, 18 have withstood 17,000 rounds of firing, seven going to 20,000, three to 26,000 and one to 34,000 rounds. Only eight extractors had to be replaced at under 6,000 rounds, and of these three failed due to improper dimensions which, of course, should have been discovered at the source.

Since these tests appeared to be satisfactory, a check is being made for use in forming various machine gun parts. These tests are still in process, but at this moment it ap-

Fig. 3 (below)—Applying primary investment by spray method.
Fig. 4 (right)—Pouring investment slurry around pattern.



pears that the results will be equally satisfactory if not more so.

Status of Precision Casting

This brings us up to the status of precision casting today. As previously mentioned, the Army Air Corps is using this process to produce substantially all of its supercharger buckets, and is at least considering the production of similar parts, some of which are substantially larger. The ability of the process to supply the demand proves that it at least warrants classification as a production process, and not as a mere laboratory or pilot line curio.

Although the process should still be classified as an art and not as a science, because technique plays a large part in its successful operation, we believe that it is safe to state that practically any common metal which can be melted can be precision cast if its melting point is below 3000° F.

This, of course, opens up several interesting possibilities, particularly during the war, since it permits of the use of stainless steel in places where it would not ordinarily be employed due to difficulty in machining. By the same token, extremely hard alloys which would not have been used previously may now be employed in spots where great wear is encountered and so attain greater durability.

Another interesting development of this process is the ability to form magnetic materials with a high degree of precision and still retain excellent magnetic properties. This has been successfully accomplished and will undoubtedly play an important part in the design of future electrical components.

Casting Finishes

The finish possible to obtain today probably should be classified as an "f" finish or better, and this can be obtained in production. Finishes as fine as 3 microns have been obtained, and 65-micron finishes are currently obtainable on a production basis.

The process is gradually progressing from the batch process used by dentists and jewelers to the continuous straight-line technique which is necessary to large production. The production process possesses at least one great advantage over the dental process in that shrinkage may be corrected by correction of the pattern size, which is, of course, not the case in dental work where the cast pieces must replace exactly the dimensions of the pattern.

As would be expected, many individuals and companies have entered this field, and these include the usual assortment of good, bad, and indifferent. Considerable care should be exercised in selecting the vendor. The mere fact that he can submit one good sample does not necessarily mean anything. It is the reproducibility of the process that counts.

Process Control

Perhaps the most important single requirement today is the matter of control as applied to every step of the procedure, as well as the materials entering into it. Without control reproducible results could not be obtained, but with control reproducibility is exceptionally high, in many instances exceeding the reproducibility normally obtainable by machining (Fig. 6).

The physical properties of such castings are exceptionally good when properly cast under controlled conditions. While there are not yet sufficient data available to make any positive statements about physical properties, it appears that in most instances the tensile strengths and yield points will be comparable to bar stock of the same composition.

Castings of SAE 4130 steel can be made to yield tensile strengths of from 90,000 to 145,000 psi., depending upon the heat treatment, and will have a reduction of area from as low as 5 to as high as 35 per cent. This could be compared with 4130 bar steel having a tensile strength of 135,000 psi. with an elongation of 22 per cent. In general, it should be assumed that the elongation and reduction of area will be lower and perhaps 60 per cent of that obtainable in bar stock.

Metallurgical Control

Metallurgy is not yet under satisfactory control in all cases. The investment is a good insulator, which results in slow cooling and, as would be expected, this results in a normal dendritic structure which can be corrected by standard heat treatment. The grain size remains fairly large, sometimes as high as three. To at least some degree this can be corrected by casting in a cooler mold, if permitted by the contour and size of the piece, and by breaking the casting out of the mold as soon as possible after pouring.

Development of a more highly heat conductive mold would be very beneficial in this respect. When the density is high, as should be the case with good control, the cast parts exhibit an unusually high resistance to wear, perhaps due to the moderate chilling effect of the mold on the skin of the casting.

The existence of porosity varies with the supplier, but where good control is exercised rejects for porosity will be less than one per cent, based on 100 per cent x-ray inspection. Chemistry is under fairly good control and is attained usually by the melting of bar stock or similar scrap of known chemistry and making the proper additions for correction of heating loss.

Aluminum is normally used to deoxidize steel melts and is sometimes present in relatively large quantities. However, this is not objectionable in all instances and could probably be corrected if the necessity arose.

Dimension Tolerances

Dimensions are finally coming under close control, and at least one firm is today able to produce steel parts having tolerances of a thousandth of an inch to the inch or better in most instances. This tolerance control, of course, varies with the difficulty of casting the part and with the time devoted to the study of proper spruing, temperatures, etc. Close tolerances (Fig. 7) should not be required if not needed, as this increases rejects and costs.

When properly employed the process shows great possibilities in cost reduction. For example, figures developed by one of the arsenals for castings which cannot be termed precision castings but which are more truly investment castings designed simply to supply the machines with more closely formed parts for machining are shown in the table. It will be noticed that the cost reduction of certain of the parts is quite remarkable.

The Armed Forces as yet have not issued any blanket approval of this method, nor could they reasonably be expected to do so since the results obtained vary with the maker of the casting, but they have approved the use of this process for the manufacture of certain specific items under special controlled conditions involv-

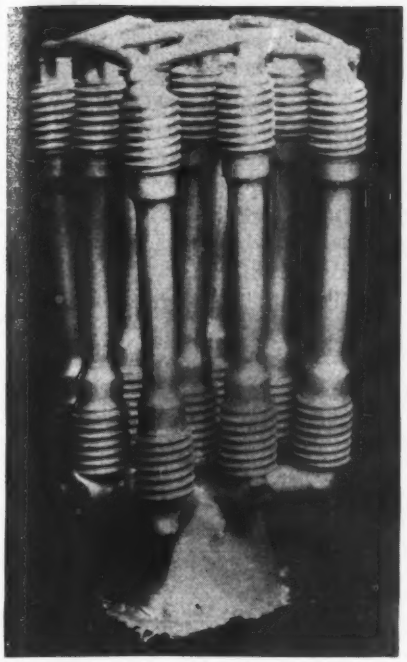


Fig. 6—Illustrating degree of precision generally available by precision casting in ferrous metals.

ing a high order of inspection. It appears to be a foregone conclusion that this will increase.

The cost of the process is still quite high and, while it varies within wide limits, a figure of 10 to 15 cents per ounce is not too far out of line for a rough estimation. This high cost is due not only to the current lack of mechanization of the process but to the high cost of the materials involved.

Costs in Precision Casting

Reclamation of pattern material is not always practical, and some loss of material is involved in every cost. In addition, the sands and binders are quite expensive. Skilled labor, fortunately, is not generally required for the process, and semi-skilled or unskilled labor can be quickly trained to perform the necessary operations.

Since spruing is very critical, both as to size and position, it is not always possible to stack the patterns in the most economical manner. This often means that only a small percentage of the metal cast goes into finished castings, and the amount of metal per lb. of sand is small. All of these factors contribute to the seemingly high cost.

The present equipment used in the process is, as will be seen later, still in its development stage, and a great many of the problems now present in the industry will disappear as the equipment is improved.

Since the process is still more of an art than a science, rejections will sometimes run quite high and are so variable that it is difficult to strike an average. One plant has reported a variation as low as 8 and as high as 80 per cent, while others figure 40 per cent as an average.

This may not present a true picture, however, since the inspection involved in these cases has been exceptionally high and the tolerances very close. A figure of 15 per cent would be as good an average as could be obtained today. These statements are deliberately quite vague since it is extremely difficult to obtain a clear picture of the status of this industry today due to the necessity for secrecy and the patent work which is always present in a new and growing field.

The process today, for practical purposes, is limited to smaller castings of the order of ¾-lb. or less. On the other hand, many larger castings have been made experimentally and could be produced commercially today if there were sufficient economic advantage.

Properties of Precision Castings

A word of caution, but this time on the credit side. If the physical properties of precision cast parts do not happen to be equivalent to the physical properties of bar stock which has been previously used in making the part, it should not be immediately assumed that the process is not suitable for making the part.

In many instances, the existence of a quality in the metal, such as tensile strength or elongation, actually may be immaterial in the functioning of the article. The real way to test is to cast the part and try it in comparison to its normal method of production. A true picture of value can be obtained in this way.

With regard to the future of the process, the writer would like to make a prediction. The prediction is that this process will probably be quite generally misapplied at first, and it is again emphasized that it should not be regarded as a cure-all. When properly applied it will cure a number of production headaches but, at least initially, its use should be confined to fields wherein it is obviously well adapted. At the moment, these fields can be fairly well defined in a general way.

This process is obviously excellent for the formation of relatively small parts made of unmachinable materials. Furthermore, it is quite well adapted to the manufacture of small, intricate parts where labor represents a large percentage of the total cost. Either of these factors, alone or in combination, would indicate that serious consideration should be given to precision casting.

Casting Design

It should always be kept in mind that the skill of the various people in the business varies, and poor initial tests from one group do not necessarily mean that the job cannot or should not be done, for another group may have the "know-how" required to make the job a success.

Before this process makes a serious impression on American industry, the author believes it essential that at least the existence of this process and its limitations get back to the designers who actually lay out the pieces. This is important for many reasons.

First of all, it gives the designer substantially complete freedom in his choice of materials. Second, he can combine in some instances several parts which were previously made as individual units for purposes of machining and form them into one unit. This is particularly important since the patterns can be assembled by means of suitable jigs and fix-

COMPARATIVE COSTS OF MACHINING AND PRECISION CASTING

	Cost of—			
Part	*Conventional Machining Methods*	*Precision Casting*	*Finishing Operations on Precision Castings*	*Precision Cast Part (finished)*
A	$ 3.79	$1.05	$1.13	$2.18
B	6.50	1.00	2.16	3.16
C	4.97	0.75	1.35	2.10
D	4.66	0.45	1.09	1.54
E	11.90	1.60	2.09	3.69
F	10.76	1.32	2.64	3.96
G	2.30	0.65	1.11	1.76
H	14.27	2.00	7.56	9.56
I	7.35	1.84	1.49	3.33

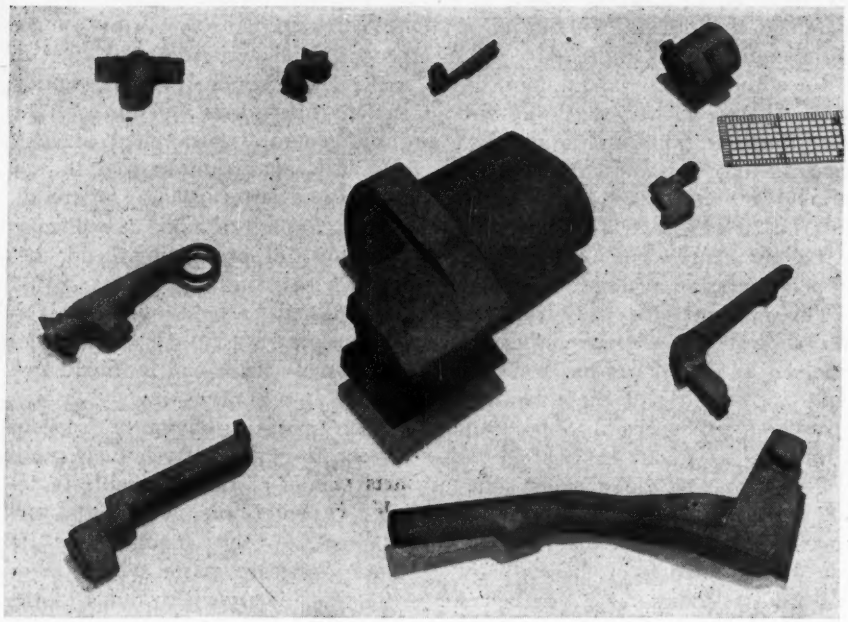


Fig. 7—Precision cast gun parts in as-cast condition. Close tolerances reduce subsequent machining costs.

tures into complex shapes after forming individually and the assembly cast as a unit.

It is important that the designer recognize that this is a casting process and, wherever possible, he should use good casting design, particularly in the incorporation of fillets, since sharp corners are always a source of potential weakness in an investment. Webbing may be employed to lessen weight, which would not be practical in ordinary design for machining.

He should not attempt, however, to design parts for precision casting which could be designed just as easily for use with automatic screw machines, punch presses or similar machines, since precision casting cannot compete on a cost basis.

Inventory Reduction

In addition to the possibility of substantially reducing machining cost and obtaining a better product, there is the interesting possibility of curing an inventory problem. For example, if we have an item or items which could be precision cast and for which we have a relatively large but sporadic demand, it is quite possible, in place of carrying a large stock of the product, to store only the die necessary to form the patterns.

The die being available, patterns can be supplied and casts made in a relatively short time, on the order of 10 days, which in normal times is sufficient to fill a good-sized order. Once this process is started the production per day with a relatively small setup is quite large and can be built up rapidly.

Still another factor in its favor is the speed with which parts can be obtained. Rather than waiting for the construction or removal from storage of jigs and fixtures, tearing down machines, etc., it would be necessary only to produce the patterns and cast the parts, a matter of a week or so, which does not disrupt either casting shop or machines.

Precision casting is not an industry into which anyone can move and do his own casting. Willingness to go through the research and development necessary to perfect the technique is necessary for success.

The effect of this process on various industries will naturally vary in almost direct proportion to the type of problems in the industry and the applicability of the process to these problems.

As for the process itself, granting that it is to assume an important place in the production picture, it is obvious that it must develop into a science and become highly mechanized with full control of all essential parts. With other improvements, such as hollow patterns, this will result in lower costs.

It is reasonably certain that a high order of accuracy and good physical properties can and will be obtainable wherever necessary, but that customers will soon realize that there is no object in paying for high precision unless it is really needed. The costs of castings will be proportional to the precision required, since the tolerances fundamentally control both inspection costs and rejections.

The author believes that there is little doubt that as the process accumulates more experience larger pieces will be cast, and that this eventually may provide a limited form of competition to some of the smaller articles normally cast in foundries. It is quite probable that 1945 will see the commercial production of 2.5 lb. precision castings, and that within 5 years precision castings weighing 10 lb. will be available.

Considerable doubt exists that the process will ever be applicable to large pieces of the type ordinarily handled in the average foundry, at least insofar as precision casting is concerned. However, this is not beyond the bounds of possibility and, as developments progress, may become more feasible than it now appears.

Acknowledgments

The author wishes to acknowledge the courtesies extended by the many organizations which have developed the various components of the precision casting process, especially to Austenal Laboratories, Inc., Chicago; General Electric Co., Schenectady, N. Y.; Allis-Chalmers Mfg. Co., Supercharger Plant, Milwaukee; Haynes Stellite Co., Kokomo, Ind., and the Illinois Precise Casting Co., Chicago, Ill.

Metropolitan Life Books On Employment of Vets

TWO studies prepared by Metropolitan Life Insurance Co., Policyholders Service Bureau, New York, deal with re-employment of war veterans and the employment of the handicapped veteran. These two booklets give many concrete examples of what large and small concerns are doing in the way of replacing and rehiring returned veterans. Personnel officials will find these very interesting.

PROPERTIES AND CHARACTERISTICS OF COMMON *Magnesium Casting Alloys*

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Midland, Mich.

BESIDES providing information on magnesium casting alloys, a particular purpose of this paper is to assist the founder, manufacturer, and design engineer in the problem of choosing the alloy most favorable for their particular application. In order to distinguish as much as possible between what is factual and what is subject to opinion, the paper is divided into two parts.

Part I presents pertinent technical data. In Part II the authors attempt to weigh these facts and to draw from them some practical working conclusions. Table 2 presents the nominal compositions of the alloys which will be covered, together with the designations commonly used in the United States and abroad. A brief historical sketch will serve to provide some perspective for the matters under discussion.

Prior to 1920, the casting alloy compositions used in Germany contained magnesium and zinc. Later, the AZG composition (Mg-6Al-3Zn-Mn) which corresponds to alloy "H"* was introduced and is still used[1]. For many years the German magnesium industry has also listed alloys of magnesium-aluminum-manganese-zinc, with aluminum in the range of 8-11 per cent and zinc up to a maximum of about 0.6 per cent.

The British magnesium industry makes use of these high aluminum-low zinc type alloys but has not looked with favor on the aluminum containing alloys with higher zinc content. The development in England has been summarized by Goddard[2], and discussions of British practice reviewed by Fox and Goddard[4,5].

In the United States at about 1920 the first casting alloys of importance were the magnesium-aluminum compositions, particularly Mg-8Al-Mn (0.0Zn). This casting alloy ("A") was used extensively until about 1937. The Mg-10Al-Mn alloy ("G") also came into considerable use about 1930.

These two casting alloys represented the entire usage in this country until about 1935. At this time the interest of the Armed Services of the United States in increased corrosion resistance of magnesium alloys in salt atmospheres led to the adoption of the high Zn containing alloy Mg-6Al-3Zn-Mn ("H").

Since "H" alloy did not offer the hardness, yield strength, pressure tightness and (in permanent mold applications) the castability comparable to the Mg-10Al-Mn alloy, there was a need for a new composition, with corrosion resistance comparable to"H" alloy, but having the previously mentioned properties.

This was provided about 1939 in the adoption of Mg-9Al-Mn-2Zn alloy ("C"), which was developed in this country** and apparently is not commercially used abroad. These two alloys have been used almost exclusively in the past few years for the production of magnesium castings in this country.

Due to the well-recognized tendency of "H" alloy to show microporosity and to the fact that "C" alloy, while much more sound, is still appreciably less sound than the original ternary Mg-Al-Mn or Mg-Al-Mn low Zn type alloys, there has been renewed interest in the utilization of the latter alloys for making pressure tight or highly stressed castings.

Table 1 has been prepared to illustrate relative practice in the United States, Great Britain, and Germany. Little is known concerning Japanese or Russian practice. The data in each case represent the approximate percentage use of each alloy in aircraft application. The German usage is deduced from examination of several captured German planes[1,16].

It is of interest that the German usage of AZG is to the extent of 25-30 per cent of their total casting requirements and always is in the as cast or as cast and annealed state. In contrast, the British do not use this alloy at all, while in the United States 75 per cent of the total production is in "H" alloy, although usually in the solution heat treated condition.

For engine parts subject to high stress, the Germans use the A9V (9Al-0.7Zn-Mn, solution heat treated) alloy, whereas U. S. practice is to use the heat treated and aged "C" or "H" alloy.

The fact that these different magnesium base casting compositions are being used for the same types of application in various countries

Relative usage in various countries from which information is available shows that the different magnesium-base alloys are being used for the same types of application. Within the range of composition of the alloys used and the present development of design and construction, the factors of design are of more importance than metallurgical factors. The majority of service failures are of fatigue origin, occurring because of inadequate design allowances for stress concentrations in the part.

*Denotes the Dow Chemical Co. alloy lettering

**This was the development of American Magnesium

and each of them successfully, brings up an important consideration which should be kept in mind in comparing these different alloys, namely, that metallurgical factors are far less important than design factors in determining the serviceability of a part, at least within the range of compositions under discussion and with the present state of development of light alloy casting design and construction.

The great majority of any cases of service failures have been of fatigue origin, and most of these fatigue failures have been the result of inadequate allowance in design for stress concentrations, brought about by the nature of the service function of the part, or more commonly such things as fillets, flanges, ribs, bolt holes and the like.

Failures are commonly noted to occur at these points in sound metal even though porosity may exist at other points in the part, often close to the point of failure. Similarly spot faces, undercuts, and marks and grooves due to poor machining cause many failures in castings.

The significance of the foregoing remarks is that in most cases serviceability is more likely to be determined by design and finish than by metallurgical factors, among which come soundness, alloy composition and condition. Thus, while the practical problem exists of choosing which alloy to use, its importance for serviceability should not be overemphasized.

Part I—Technical Data

The factual data are presented in three tables. Table 2 gives the properties as determined from standard test bars and various laboratory controlled experiments. Table 3 shows the properties obtained from bars cut from actual production castings. Rather than to test bars cut from castings it would be more conclusive to study field service comparisons of complete parts made from the various alloys. However, at the present time such comparisons are not available.

Table 4 lists "Foundry Characteristics." It will be recognized that some of these items, such as weldability, are necessarily qualitative. For the most part, the data in Table 4 came from observations of foundry behavior of casting alloys as handled on a commercial scale.

Table 1

RELATIVE MAGNESIUM PRACTICE

	United States	*Great Britain**	*Germany**
6Al-3Zn-Mn	H; AM-265	.....	AZG
Percentage of Production	75		30
AC (or ACS)	.....		Lightly Stressed Engine Castings
HT	Wheels		.....
HTA	Engine Parts		.....
9Al-2Zn-Mn	C; AM-260	.....	.....
Percentage of Production	24		
HTA	Engine Parts		
8Al-Mn (0.4 Zn)	A	A8	A8
Percentage of Production	.....	85	45
ACS		Miscellaneous small Parts	
HT		Wheels, Engine Parts	Wheels, Highly Stressed Engine Parts
9Al-Zn-Mn	R; AM-263	A9	A9
Percentage of Production	(Die Castings)	15	20
HT		Pressure Tight Applications	Engine Parts
10Al-Mn	G	A-10	A-10
Percentage of Production	1	.....	.....
HTA	Engine Parts (Perm. Mold)		
3Al-1Zn-Mn	.....	.....	AZ31
Percentage of Production			5
AC			Pressure Tight Applications

*Approximate proportional usage.

Composition and Properties

(Explanatory Notes to Table 2)

Density and Electrical Conductivity. The density and some of the conductivity data are from the 1944 "Dowmetal Data Book[6]." The remaining conductivity data are from other sources[10, 16].

Growth. Age hardenable magnesium alloys have the characteristic of occupying the least volume when in a single-phase condition. Conversely, they expand in direct proportion to the precipitation of a second phase and, hence, occupy maximum volume when fully precipitated. This phenomenon of increase in volume is known as growth.

The figures presented here represent the ultimate amount of unit dimensional growth that may occur on a given alloy and state due to further holding at elevated temperature (over 150° F.). The values given for the heat treated state, therefore, represent the maximum amount of growth that can be shown for that alloy composition.

The data given for "G" alloy are from Talbot and Norton[7]. The data were obtained for each condition by measuring the total increase in length of a 6-in. bar to the nearest 0.001 in. during an anneal at 350° F. The 350° F. anneal was continued until no further length changes occurred. This temperature was chosen as a standard for growth measurement since a maximum amount of aging in a relatively short time is obtained at that temperature.

Measurements at higher temperatures yield lower growth values since not as much precipitation occurs, while at lower temperatures essentially the same growth values are obtained, but very long periods of time may be required. Even magnesium alloys which have not been stabilized do not show any appreciable growth over a period of years at temperatures less than about 150° F.

In fabrication and use, growth

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Written discussions of this paper are solicited for publication in future issues of "American Foundryman" and/or bound volume of "Transactions." Discussions should be sent to Secretary, A.F.A., 222 West Adams St., Chicago 6.

may be of consequence if solution heat treated parts are used and are permitted to get hot for prolonged periods during machining, paint baking, or service. Extremely long parts that must be joined in assembly, or accurate instrument parts should be used in the de-growthed (aged or stabilized) states unless always used at temperatures less than 150° F.

Growth phenomena are not peculiar to magnesium alloys, and, as a matter of fact, age hardenable aluminum base and zinc base casting alloys show as much or more growth.

Corrosion. The first values given here are typical corrosion rates as determined by alternate immersion tests in 3 per cent NaCl solution. These values are somewhat a measure of corrosion in salt atmospheres, but they do not represent the relative corrosion rates of the various alloys in normal exterior exposure.

Figure 1 presents data indicating the effect of zinc on the corrosion behavior of commercial purity alloys. It will be observed that in general the corrosion rates of the German alloys, as shown by the crosses and circles, check fairly well with the American experience, as shown by the solid line.

The second two values, given for "H" and "A" alloys only, represent the corrosion behavior in two types of atmosphere. The first is a severe marine exposure, the second a severe industrial exposure. For the atmospheric tests the corrosion is expressed in terms of the percentage loss in tensile strength after exposure.

The effect of high zinc is of consequence only on commercial purity alloys[8]. Zinc exerts a specific effect to inhibit the bad corrosion effect of impurities such as iron, copper and nickel. If iron is held to a maximum of 0.002 per cent, nickel to 0.001 per cent and copper to 0.05 per cent, all of the compositions will show salt water corrosion rates of less than 0.2 mg/cm²/day, and, in fact, the low-zinc alloys will be slightly better.

Tensile Data. Properties are given at both room temperature and 300° F., the latter being selected as representative of the upper temperature range in which magnesium castings are normally used. Notched bar data were determined with a cylindrical notch having a radius and depth equal to one-tenth the root diameter.

This notch has a stress concentration factor of 2.4 in tension. Compression yield strengths are not given, since they are approximately the same as tensile yield strength data for magnesium alloy castings. The results are averages of from several hundred to several thousand test bars in each case.

Fatigue. These values were obtained by the R. R. Moore rotating beam method using sound, polished, separately cast test bars. Notched data in this case were obtained on similar bars machined to 0.300 in. and with a cylindrical notch having a radius and depth equal to one-tenth the root diameter. The stress concentration factor of this notch is 2.0 in bending.

In order to present a better picture of the fatigue strength, data are given at both 10^6 and 10^8 cycles. The values are the averages of a reasonably large number of tests. The figures are probably significant to plus or minus 1,000 psi. at fatigue strengths of 10,000 psi. or over, and

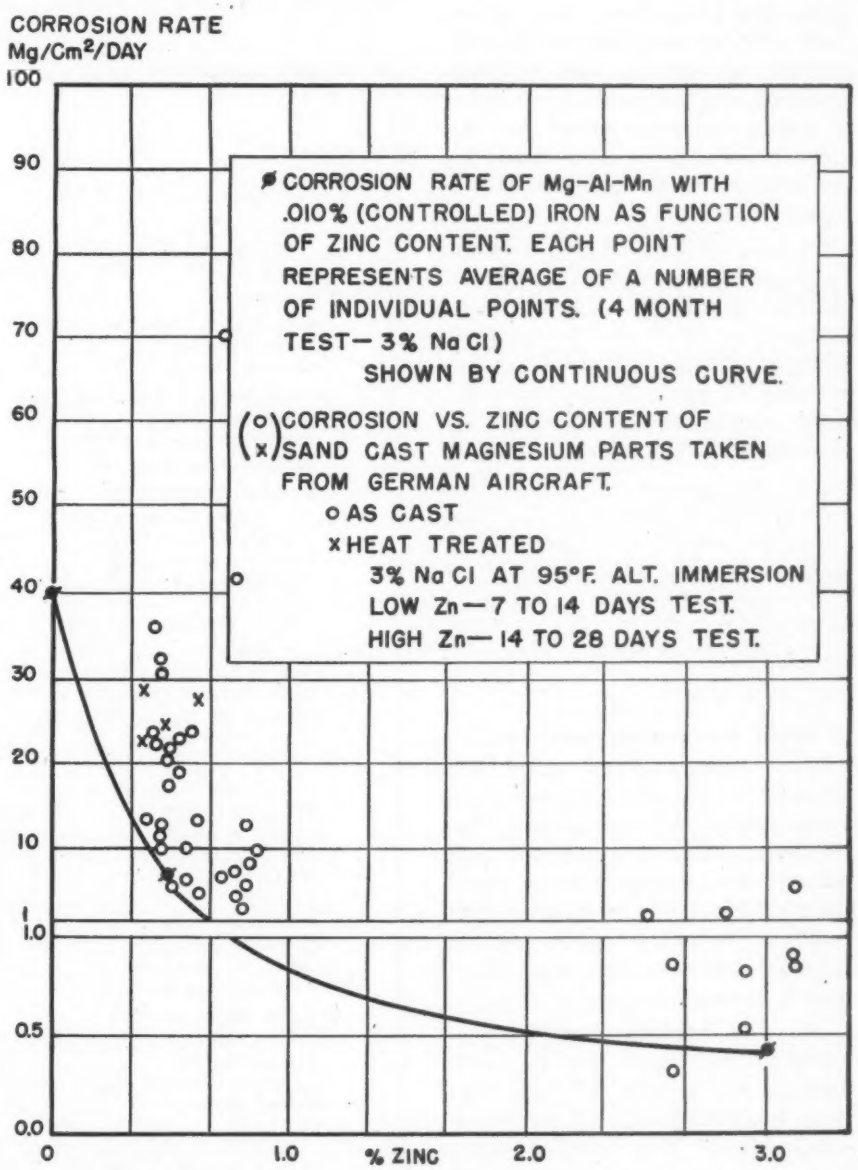

Fig. 1—Corrosion rate vs. zinc content in magnesium alloys. Comparison of German and American alloys.

to plus or minus 500 psi. at values under 10,000 psi. Here it will be noted that 275° F. was chosen for the elevated temperature data.

Plain Charpy Impact, Shear Strength, and Brinell Hardness. The shear strength and Brinell hardness are from the 1944 "Dowmetal Data Book[6]." The Charpy tests were run on bars conforming to standard dimensions, with the exception of slightly rounded edges. These were present because the specimens were machined from 0.5 in. diameter cylinders. The values given are therefore slightly lower than would normally be obtained, but the relative relationships are not changed.

Properties from Production Castings

(Explanatory Notes to Table 3)

Although a large amount of information of a qualitative nature was available as a result of sporadic attempts to compare alloy compositions, this did not seem adequate for a semi-quantitative study of the relative behavior of these alloys for the production of commercial castings.

In view of this situation, a definite program was followed in the production foundry to evaluate three different types of alloy composition in the sand foundry and four different types of alloy composition in the permanent mold foundry. We shall first discuss the sand foundry tests.

For this purpose "H" alloy, representing the ductile, high zinc, low aluminum type; "C" alloy, representing the high strength, pressure tight type; and a third composition, Mg-9Al-0.2Mn-0.0Zn, representing the ductile, low zinc, high aluminum type, were chosen.

Metal and Pouring Conditions

Two commercial patterns were selected for the test; one being an aircraft engine oil pan casting (Fig. 2B) of large area and relatively thin sections, the other an aircraft wheel casting (Fig. 2C) containing thin and also relatively heavy sections and representing a part where ductility is important.

These castings are normally produced in "H" alloy. For the comparison, ten castings of each part were made in each of the three compositions. The melting, refining, superheating, and pouring temperatures were all held constant, and all foundry details were maintained under as nearly identical conditions as possible.

The castings were then radiographed quite thoroughly. These two types of castings are referred to as nos. 1 and 2 on Table 3, and a qualitative radiographic rating is there noted. The low zinc type alloy was better radiographically than the "C" alloy, which in turn was better than the "H" alloy. The castings were then tested as heat treated in the case of the wheel, and both as heat treated and as heat treated and aged in the case of the pan.

Test pieces were taken from each of the alloys and tested for corrosion in 3 per cent NaCl solution. These data are shown on Table 3. Three castings from each alloy and each part were cut in such a way as to get the largest possible number of test coupons from the casting. These were given the standard tensile tests, the average results of which are given in Table 3.

The values shown under the heading "Minimum" represent a value of each property which would be exceeded by 95 per cent of all the individual bars cut from the two different types of production castings. This is given as a measure of the dependability, or the probability of getting a certain level of properties in the actual castings.

Casting no. 3 (Fig. 2D) was handled in substantially the same manner as the preceding two castings, but with the inclusion of R. R. Moore fatigue tests on 20 bars cut from various locations.

Another type of casting was made in the experimental foundry (Fig.

Table

COMPOSITIONS AND PROPERTIES OF

ALLOY DESIGNATIONS	"C"					"H"				
Dow										
Other	*AM-260, ASTM No. 17*					*AM-265, ASTM No. 4, (MEL) AZG*				
Composition, per cent	*9.0 Al—0.13 Mn—2.0 Zn*					*6.0 Al—0.18 Mn—3.0 Zn*				
Condition	*AC*	*ACS*	*HT*	*HTS*	*HTA*	*AC*	*ACS*	*HT*	*HTS*	*HTA*
PHYSICAL										
Elec. Cond., mho-cm^{-1} × 10^{-4}	7.1		5.5		7.2	8.1		6.7		8.0
Density gms/cc	1.82					1.83				
Growth (Unit) × 10^{-4}	3.4	1.7	7.6	2.1	2.9	2.6	1.2	5.4	2.7	2.2
CORROSION OF BARE METAL										
3 per cent NaCl [5]	4		10		6	1.5		4		2
Coastal Atmosphere [6]						12		22.5		
Industrial Atmosphere [7]						3		5		1
TENSILE[4] PROPERTIES										
Room Temperature										
Tensile Strength (plain)	24.0	25.0	40.0	40.0	40.0	30.0	30.0	40.0	40.0	40.0
Yield Strength (plain)	14.0	14.0	16.0	20.0	23.0	14.0	14.0	14.0	17.0	19.0
Elongation (plain), per cent in 2 in.	2.0	2.0	10.0	3.0	2.0	6.0	5.0	12.0	7.0	5.0
Tensile Strength (notched)	22.5		34.5		37.0	27.0	27.5	37.5	37.5	35.5
300° F.										
Tensile Strength (plain)	26.0	24.0	31.0	28.0	28.0	27.0	26.0	29.0	27.0	24.0
Yield Strength (plain)	15.0	13.0	17.0	17.0	18.0	13.0	13.0	12.0	14.0	15.0
Elongation (plain), per cent in 2 in.	9.0	4.0	30.0	38.0	38.0	25.0	14.0	15.0	15.0	15.0
FATIGUE[4] (R. R. Moore)										
Room Temperature										
10^6 Cycle (plain)	16	16	18	17	18	12	18	17	18	17
10^5 Cycle (plain)	13	13	16	13	15	10	12	16	15	15
10^6 Cycle (notched)	10		14	12	11	10	10	12	12	11
10^5 Cycle (notched)	8		12	9	9	7	9	8	9	9
275° F.										
10^6 Cycle (plain)	15	9		12	13		11		11	12
10^5 Cycle (plain)	9	8		9	10		8		9	7
10^6 Cycle (notched)	8	6		8	9		7		7	8
10^5 Cycle (notched)	5	4		4	6		6		5	5
OTHER PROPERTIES[4]										
Plain Charpy Impact, ft. lb.	2.3		16.5		4.4	4.7		34		8
Shear Strength	18.0		20.0		21.0	18.0		19.0		20.0
Ultimate Comp. Strength	55.0		60.0		70.0	45.0		46.0		50.0
Brinell Hardness	65		63	75	84	50		55	59	73

*Primarily the data refer to sand and permanent mold castings.
[1] MEL A-9 may contain 0.6 per cent max. Zn.
[2] MEL A-8 may contain 0.4 per cent max. Zn.
[3] Maximum.

2E), with the advantage that it could be cut to give a good survey of the effect of casting shape on tensile properties; that is to say, bars could be cut in such a way as to represent four different design situations which might be typical of those found in production castings as follows:

1. A heavily chilled area.
2. A section where two walls intersect to form a cross.
3. A gate area.
4. A relatively thin area which would be difficult to feed.

Test Coupons

This casting also permitted the cutting of test coupons which would be tested in fatigue. This casting is designated as no. 4, and the average tensile and fatigue properties are shown in Table 3. In the case of the fatigue data (R. R. Moore), the values were obtained on polished bars cut from three selected positions as follows:

Sound position was from a heavily chilled area.

Unsound position was from a porous area adjacent to the gate.

Intersecting Wall position was selected in moderately sound metal, but so chosen that the bar was machined with the reduced section of the fatigue bar including the metal originally at the point of casting wall intersection.

For the evaluation of alloy compositions in the permanent mold foundry three patterns (Fig. 2F) were selected. In each of these, four compositions, "C", "H", "R", and "G" alloys were tested. Average tensile data on test bars cut from these castings (casting nos. 5, 6, and 7) are as shown in Table 3.

Table 2

MAGNESIUM ALLOYS—CASTINGS*

"R" AM-263, ASTM No.13, MEL A-9[1] 9.0 Al—0.15 Mn—0.7 Zn					"G" AM-240, ASTM No. 2 10.0 Al—0.13 Mn—0.3 Zn			"A" MEL A-8[2] 8.0 Al—0.3 Mn—0.3 Zn[3]		
AC	ACS	HT	HTS	HTA	AC	HT	HTA	AC	HT	HTA
7.1		6.0		7.6	6.7	5.5	7.2	7.6	6.7	7.2
1.81					1.81			1.80		
4.0	2.1	7.7	2.6	3.6		21.0	10.0			
17		24			20	50	30	17	25	
								22	45	
								2	5	7
25.0	25.0	40.0	40.0	40.0	24.0	39.0	39.0	30.0	39.0	39.0
14.0	14.0	14.0	18.0	21.0	16.0	14.0	20.0	12.0	11.0	16.0
4.0	3.0	12.0	4.5	4.5	1.0	10.0	2.0	5.0	13.0	7.0
24.0	22.0	35.5	36.5	36.0						
	25.0		27.0	27.0			28.0			27.0
	13.0		15.0	14.0			14.0			10.0
	7.0		30.0	40.0			30.0			26.0
	16	18	15	15	16	18	16			
	12	15	12	10	12	14	11			
	10	12	10	10	10	12	11			
	6	9	7	7	7	8	9			
	11		13	11						
	9		10	7						
	7		7	6						
	5		5	4						
2.6		32.4		4.2	2.6	17.2	4.6	3.8	37.2	14.7
					17.0	19.0	21.0			
					48.0	50.0	54.0			
52	59	53	64	66	54	52	69	52	50	56

[1] All stress values in units of 1,000 psi.
[2] 14-day test by alternate immersion (95° F.). Expressed as loss in weight—mg/cm²/day.
[3] Exposed 4 yr. in racks 80 ft. from ocean surf. Expressed as per cent loss in tensile strength.
[4] Exposed 4 yr. in racks at Midland, Mich. Expressed as per cent loss in tensile strength.

Foundry Characteristics

(Explanatory Notes to Table 4)

Freezing Range. This represents the range encountered in production castings between the liquidus temperature and the temperature at which the final liquid solidifies. Two figures are given for each case. The first one is the difference between the liquidus and the solidus temperature for the alloy[10]. This is the range to be expected under equilibrium conditions and represents a minimum for any freezing condition.

The second figure is obtained by first determining the melting point of the lowest melting constituent in a sand casting, considering this temperature as a "non-equilibrium solidus," and then expressing the freezing range as the difference between this temperature and the liquidus. This latter range is the one most closely approached in all practical casting operations.

Fluidity. These are data obtained with the standard A.F.A. fluidity spiral of trapezoidal cross section when cast at 1400° F. The reproducibility is about ± 1 in.

Castability. This is the general ability to fill a mold and give adequate reproduction of shape and detail without excessive casting defects. The data given were based on the production castings listed in Table 3.

Pattern Shrinkage. Pattern shrinkage is defined as the linear change in inches per foot as the casting cools from the molten state at the pouring temperature to room temperature. It is the same for all compositions and equal to about 5/32 in. per ft. This figure can vary within rather wide limits, depending upon restraint conditions present.

Melting Loss. These data were obtained on a continuous melting, alloying, and casting cycle, wherein about 50,000 lb. of each alloy were accurately weighed in and out. The melting loss represents one cycle of melting, alloying, and pouring. The data were obtained on "C", "H", and "G" alloys, and the values given for "R" and "A" alloys were estimated by consideration of their similarity in composition and known behavior.

It should be appreciated that

these are indications of the relative melting losses under one particular set of melting conditions, and the absolute values may be considerably lower under more favorable conditions.

Porosity Tendency. Here the alloys are rated on the basis of the relative amounts of radiographic porosity in a standard porosity test panel (Fig. 2A). Zero (0) is least porosity. This porosity panel has been described by Busk, Marande, and Newhams[11], and is a flat, rectangular panel attached to a tension test bar mold.

It is so gated that it will show a small amount of porosity even in the soundest alloy compositions. It will be appreciated that this is a drastic test, and alloys that would show unsoundness on this panel might show a better degree of soundness in actual production castings.

Pressure Tightness. This again is a qualitative rating wherein one (1) is best. The tests were made on a standard hollow cylindrical casting gated and poured under identical conditions for each alloy (Fig. 2A). All of the alloys can be made pressure tight, but the figure given is a qualitative indication of the relative ease with which pressure tightness is accomplished.

Hot Cracking Tendency. Hot cracking is not a problem unless excessive restraint is present, such as may be the case in the permanent mold foundry or with large steel inserts in the sand foundry.

Cold Brittleness. This is a qualitative rating representing the likelihood of breakage in handling and straightening a cold casting. One (1) is best. None of the alloys is especially bad as compared to other structural metals.

Grain Size. The magnesium alloys represented in this table are all

Table 3

PROPERTIES OF BARS CUT FROM SEVEN DIFFERENT PRODUCTION CASTINGS

Casting No.	Type Casting	Type Average	Test[1]	Alloy "C" HT	"C" HTA	"H" HT	"H" HTA	"R" HT	"R" HTA	"G" HT	"G" HTA	"A"[4] HT	"A"[4] HTA
1	Sand	Arithmetic mean	T.S.	41	41	37	36					36	38
			Y.S.	19	23	14	19					14	20
			Per cent E.	7.2	2.5	10.3	4.2					9.7	3.4
		Minimum[2]	T.S.		29		24						31
			Y.S.		20		12						17
			Per cent E.		0.2		0.5						0.5
		Arithmetic mean	3 Per cent NaCl[3]		3.73		0.75						8.34
			Radiographic Rating		2		3						1
2	Sand	Arithmetic mean	T.S.	32		30						30	
			Y.S.	19		13						14	
			Per cent E.	2.5		5.9						6.3	
		Minimum[2]	T.S.	20		20						18	
			Y.S.	13		11						11	
			Per cent E.	0.5		1.5						1.5	
		Arithmetic mean	3 Per cent NaCl	12.9		6.4						32.0	
			Radiographic Rating		2		3						1
3	Sand	Arithmetic mean	T.S.			31.4						32.4	
			Y.S.			14.1						13.5	
			Per cent E.			6.5						10.2	
	Sound Area	10^8 Cycles	Fatigue			10.0						11.0	
	Unsound Area	10^8 Cycles	Fatigue			7.5						11.0[5]	
4	Sand	Arithmetic mean	T.S.	30.6	35.4	31.5	33.6	34.8	33.5	33.4	35.3	33.8	35.9
			Y.S.	14.7	21.2	12.3	17.6	11.7	15.4	15.1	22.0	12.9	18.7
			Per cent E.	5.9	2.0	7.9	3.3	10.2	5.0	6.8	1.3	8.6	3.7
	Sound Area	10^8 Cycles	Fatigue	16.5	15.0	15.1	12.0	15.5	12.1	15.0	12.0	11.2	10.5
	Intersecting Wall	10^8 Cycles	Fatigue	13.0	10.5	10.8	11.1	15.0	9.8	11.5	11.0	11.5	9.0
	Unsound Area	10^8 Cycles	Fatigue	9.0	8.0	9.8	10.0	11.5	10.0	10.8	10.9	11.5	10.0
5	Permanent Mold	Arithmetic mean	T.S.	32	32	27	29	27	27	30	26		
			Y.S.	16	22	13	16	13	15	15	22		
			Per cent E.	5.4	1.3	4.2	2.7	6.0	3.6	7.0	2.3		
6	Permanent Mold	Arithmetic mean	T.S.	30	29			27	27	23	28		
			Y.S.	14	20			14	21	15	22		
			Per cent E.	1.2	1.8			3.0	1.8	1.4	1.3		
7	Permanent Mold	Arithmetic mean	T.S.	28	28	30	30	31	28	27	30		
			Y.S.	18	22	15	19	16	20	14	18		
			Per cent E.	1.7	0.6	6.3	3.5	6.0	3.7	5.7	3.2		

[1] All stress figures are in units of 1,000 psi.
[2] The property value which 95 per cent of all specimens will exceed.
[3] Corrosion rate in mg/cm²/day during alternate immersion.
[4] These tests were purposely made with Mg + 9 per cent Al + Mn which is at the top limit of "A" alloy.
[5] Bars from this area when poured in "A" alloy were sound, and therefore had the same fatigue limit as the bars from the "sound" area.

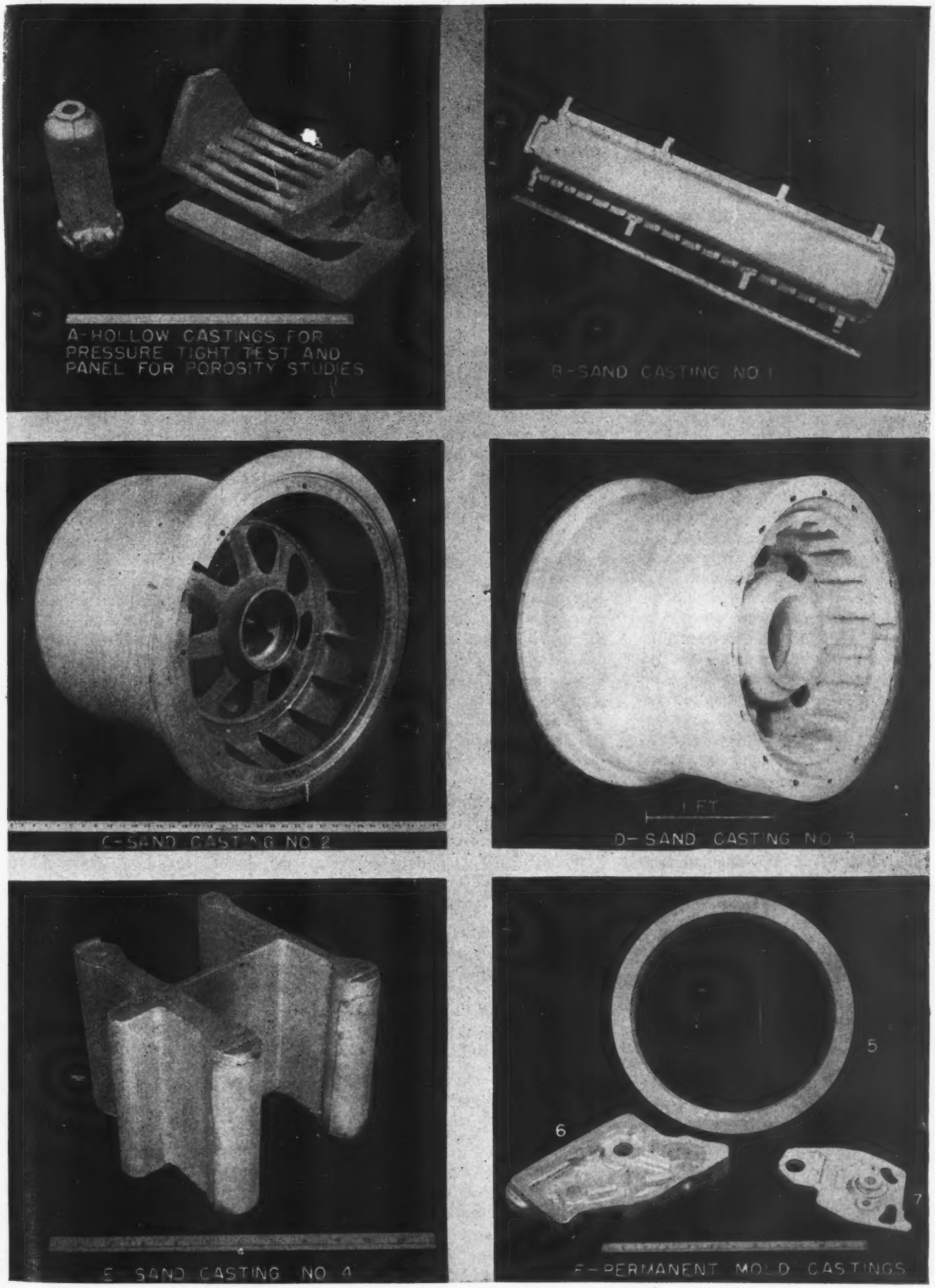

Fig. 2—Types of magnesium alloy castings used for the various tests.

amenable to grain refinement by the commonly known refining and superheating treatments[12]. When such treatments are properly given, the grain sizes will all be about equally fine and of the order of 0.004-0.006 in. average grain diameter.

Germination Tendency. This is a semi-quantitative rating of the relative tendency of the alloys to grow excessively large grains during solution heat treatment. Zero (0) refers to no germination.

It should be kept in mind that the occurrence of germination is an abnormal phenomenon and is avoidable in all of these casting compositions by correct chilling and molding conditions, care in handling the castings after shake-out to avoid cold work, and the use of the proper solution heat treatment method[13].

Commercial Heat Treatments

Heat Treatability. This behavior of the alloys is expressed by the number of hours at the proper temperature to give a commercially acceptable degree of homogenization. These are commercial treatments and the temperatures used were selected to provide a compromise between time for treatment and avoidance of fusion voids and sagging. A compound rating of 4 or less is considered satisfactory[14].

It is common practice to give the "H" and "C" (high zinc type) alloys a 2-hr. pretreatment over the range from 500° F. up to the heat treating temperature in order to avoid fusion of the lower melting phases prior to the regular heat treating step. These two hours should be added to the time for the high zinc compositions, since the low zinc alloys do not require this pretreatment.

The specific temperature of 500° F. is not chosen for metallurgical reasons, but for production convenience. This temperature should not be higher than 640° F. In practice the 2-hr. preheat has little significance, since most large production furnaces require at least that long to reach heat treating temperatures after unloading and reloading with a cold charge.

It can be seen from Table 4 that addition of zinc will increase the rate of homogenization of Mg-Al-Mn alloys. Thus, "R" alloy, with 9 per cent Al and 0.7 per cent Zn, requires 18 hours at 780° F., while C alloy, also with 9 per cent Al but 2 per cent Zn, can be equivalently heat treated 10° F. lower in the same length of time. The significance of this 10° F. drop is shown by the fact that the time necessary for heat treatment of "R" alloy is about doubled when the temperature is 770° F.

A qualitative rating of the tendency of the various alloys to sag during the solution heat treatment suitable to each alloy is given, one (1) being the least amount of sagging. This was obtained by supporting a test bar of each composition during its standard heat treatment as a loaded cantilever beam and then noting the relative permanent deflection. In general, with each alloy this sagging tendency is proportional to the temperature.

Weldability. The figures given are a qualitative rating of the ease with which these alloys may be welded, one (1) being the best. The low zinc containing alloys show less tendency to crack at the bead during welding.

Machinability. There are no significant differences in these alloys. All have excellent machinability.

Part II—Evaluation

As has been previously pointed out, this section will deal with interpretation of the data presented and may, therefore, be considered with the thought that the conclusions reached represent opinion based on experience; other circumstances might lead to somewhat different conclusions.

It must first be recognized that all of these alloys are compositions within one system—Mg-Al-Mn-Zn. Therefore, many of the physical and mechanical properties are interdependent, and all of them change in a gradual manner from one alloy to another.

Equivalent mechanical properties can be secured with Mg-Al-Mn or by adding Zn and reducing the aluminum proportionately. Any selection of a specific composition is thus somewhat arbitrary within the general framework of the system as a whole.

Examination of Table 2 reveals that, within the alloy system with which we are dealing, two general classifications of mechanical properties exist. First, there are those alloys possessing high hardness and strength, but with somewhat limited ductility and toughness. These are compositions containing a relatively high total alloy content (> 10 per cent).

Second, there are those alloys having high ductility and toughness, though somewhat lower hardness and strength. These compositions are characterized by a lower total alloy content (< 9 per cent). Within each of these classes a further choice concerning the ratio of Zn/Al can be made.

For the high strength, high hardness class it is concluded that the most suitable composition is "C" alloy. This conclusion is reached because "C" alloy is relatively good in soundness, weldability, and corrosion, and responds uniquely to special quenching and aging heat treatment procedures[15].

Thus, in this range of possible compositions neither a high nor a

Table 4

FOUNDRY CONSIDERATIONS

	Alloy				
	"C"	*"H"*	*"R"*	*"G"*	*"A"*
Liquidus, ° F.	1106	1135	1110	1100	1120
Freezing Range, ° F.	310/350	350/450	275/320	260/300	225/275
Fluidity (A.F.A. in.)	30	25	26	26	23
Castability	1	1	1	1	1
Pattern Shrinkage, in./ft.	5/32	5/32	5/32	5/32	5/32
Melting Loss, per cent	2.5	2.0	3.0 (est.)	3.5	3.0 (est.)
Porosity Tendency	2	4	1.5	1	1
Pressure Tightness	2	3	1	1	1
Hot Cracking Tendency	1	2	1	1	1
Cold Brittleness	3	1	2	4	1
Grain Size	Fine	Fine	Fine	Fine	Fine
Germination Tendency	3	0	3	4	2
Heat Treat (hr. at ° F.	18/770	10/730	18/780	18/780	16/790
Heat Treat Sagging	3	1	2	2	2
Weldability (Hot)	2	3	1	1	1
Machinability	Excellent	Excellent	Excellent	Excellent	Excellent

low Zn/Al ratio is chosen, but rather a uniquely good compromise. However, if soundness as such is the prime requisite, dropping the Zn and raising the Al is a commercially successful and demonstrated alloy (e.g., "G" alloy).

In the low total alloy range no such fortunate compromise has been found and we must, therefore, compare high zinc (3 per cent) and low zinc alloys. The mechanical properties of these alloys, as shown in Table 2, are too much alike to permit selection on this basis.

We are, therefore, privileged to make a choice on the basis of the more qualitative factors listed in Table 4, reference to which reveals that appreciable differences exist in six properties: porosity tendency or pressure tightness, hot cracking tendency, germination, heat treatability, weldability, and salt water corrosion.

Permanent Mold Castings

Of these, the high Zn/Al ratio type is superior in three cases (germination, heat treatability, and salt water corrosion), while the low Zn/Al ratio type is superior in the remaining three (porosity tendency, hot cracking tendency, and weldability). The question of relative importance of these properties must be examined.

One of the characteristics—hot cracking tendency—need be considered only in connection with a permanent mold type of casting. There it is of sufficient importance to rule out a high Zn/Al ratio for any but the simplest of shapes. Thus, for permanent mold, in general, the choice of alloys should be "C" alloy for high strength and a low Zn alloy (e.g., "A" alloy) for toughness.

Since hot cracking is not a limiting factor in the sand foundry, this property can be neglected in selecting an alloy for this type of fabrication. Thus, a balance must be made between the importance of low porosity tendency and good weldability on one hand, and low corrosion sensitivity to impurities, ease of heat treatment, and no germination on the other hand. Emphasis upon one property or another is responsible for the choice of alloy for any particular application.

In order to check the properties of the metal found in commercial castings when poured in different alloy compositions, the four types of castings listed in Table 4 were made. With all four types of casting the "A" alloy was substantially more sound than the "H" alloy.

In spite of this the very interesting fact is apparent that in three of the four castings the properties of test bars cut from the castings—both tensile and fatigue—are equivalent for the "H" and "A" alloys. In the remaining casting (no. 3) the "H" alloy was sufficiently more porous than the "A" alloy in one section of the casting to lower the fatigue strength of test bars cut from the casting.

Porosity Control

There is no clear correlation of these test bar results with the serviceability of the casting. Porosity will have little influence in the practical matter of the serviceability of the casting, unless the porosity occurs in a location at which failure might initiate even if the metal were sound.

Control over the location of porosity is possible by the foundryman, but he does not always know which regions of the casting are to be the ones most critically stressed in service. An absence of radiographic porosity possesses certain psychological advantages and is of unquestioned value in those cases in which pressure tightness is a service requirement.

With alloy compositions containing more than 0.3 per cent zinc, there is a distinct increase in radiographic porosity[16]. Thus, although the mechanical properties of the low zinc alloys used by the British (0.4 per cent and 0.6 per cent Zn) are not significantly different from alloys containing no zinc, the advantage of the good soundness characteristics of the low zinc alloys is more fully obtained when the zinc is held to a maximum of 0.3 per cent.

Thus, while the term "low zinc" has been generally used in the discussion of this paper, this means preferably zero per cent Zn with an allowable maximum of 0.3 per cent.

Alloy Weldability

Weldability of casting alloys is a practical consideration which is of value both because of the adaptability of the castings to fabrication processes involving welding, and because of the economics of salvaging castings with small foundry defects.

Although salvage welding is not used, or used in only limited ways on aircraft castings, it should be at least as economically important in the peacetime commercial field as it is for steel foundries.

The atmospheric corrosion results in Table 2 emphasize the arbitrary nature of salt water corrosion testing. For exposures in a severe marine atmosphere the relative results obtained in a salt water alternate immersion test remain approximately true. However, for other more normal types of exposure, even in severe industrial atmospheres, both the high and low zinc types of alloy are quite similar in behavior.

Both are very stable, as shown by the fact that strength losses of bare metal in 4 years' exposure amount to only a few per cent. If painted, there is no loss in mechanical properties. Thus, the severity of the anticipated exposure determines how much emphasis should be placed upon salt water corrosion resistance.

Low Zinc Alloys

Low zinc alloys not of high purity grade are used for aircraft parts, wheels, engine parts, air frames, etc., by the English and the Germans with apparent satisfaction. In the military service in the United States a higher standard for salt water corrosion has been set and the high zinc alloys are specified for castings (and controlled high purity magnesium alloys for wrought metal products).

It has been shown[8] that if certain impurities are controlled high zinc is not necessary for salt water corrosion resistance. Controlled purity alloys, whether with high or low zinc, will have a corrosion rate of 0.2 mg/cm²/day in 3 per cent NaCl solution and will show no loss in mechanical properties under the coastal or industrial atmospheric exposures as listed in Table 2.

Care in paint protection schedules and in design to take care of contact with dissimilar metals and of pockets likely to trap water are most effective in securing good stability in service.

As can be seen from Table 4, the substitution of Zn for Al to maintain a constant total alloy content results in shorter times of heat treatment at a given or lower temperature. "H" alloy is considered the easiest to heat treat because it can

be homogenized more rapidly and the temperature is low enough so that little trouble with sagging is experienced.

Difficulties that have been mentioned[2] are due to lack of close temperature control of the heat treating furnace, which control is desirable in any case. For the high zinc alloy mechanical properties are good without heat treatment, while improved toughness may be obtained by a heat treatment which is easy and rapid. No special precautions against germination need be taken.

The high zinc type alloy should be of particular value in the secondary metal field because of its relatively greater tolerance for impurities.

The conclusion is reached that two alloys should be available in the ductile, tough alloy class. First, there is an alloy with low zinc characterized by soundness and good weldability. This composition should be used for critical parts and high quality, specialized work. The optimum composition within this class is represented by compositions of Al < 9 per cent, e.g., "A" alloy (maximum of 0.3 per cent Zn).

Second, there is an alloy with high zinc characterized by good tolerance for impurities together with good heat treatment characteristics. This alloy is ideally suited to low cost operation when soundness specification is not critical.

Secondary metal can be used. The optimum composition within this range is "H" alloy. When the criterion for serviceability is maximum resistance to salt water corrosion, the high zinc alloy is the presently available better choice.

Data on the physical and mechanical properties of the various common casting alloys as obtained from laboratory test bars and as actually found in typical commercial castings, together with information on how these alloys behave in foundry and fabrication processes have been presented.

Summary

It has been further pointed out that all of these alloys are essentially of one family—Mg-Al-Mn-Zn—and, therefore, their properties are interdependent. Since service requirements are different, no one composition will satisfy all the needs. In view of this fact and the importance to both foundry and fabricator of keeping the number of different alloys to a reasonable minimum, three compositions have been selected as suitable for most service requirements.

Since the mechanical properties seem to be substantially equivalent, the choice between high and low zinc alloys has been based upon other characteristics. Future research may show alloy differences in response to treatments, or in other mechanical properties which will affect serviceability and may, therefore, outweigh some of the qualitative or economic considerations leading to the following compositions:

1. For applications requiring maximum yield strength and hardness, only fair toughness, good soundness, and good salt atmosphere corrosion resistance, "C" alloy is indicated. This applies equally to sand and permanent mold castings.

2. For applications requiring maximum toughness, only fair hardness and yield strength, maximum soundness and weldability, a low zinc alloy with Al < 9 per cent, e.g., "A" alloy, is indicated. For maximum salt atmosphere corrosion resistance in this alloy, purity must be controlled. This applies equally to sand and permanent mold castings.

3. For general sand casting applications requiring maximum toughness, only fair hardness and yield strength, maximum salt atmosphere corrosion resistance and tolerance to impurities, "H" alloy is indicated.

The benefits of present alloy composition factors can be completely attained only after the best design and fabricating practices have been sought out and fully applied.

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Chicago Foundryman Is Music Festival Winner

FOUNDRYMEN are proving time and time again that their skills are not only directed to making better products for better living, but also that they are capable artists in other fields.

R. F. Dalton, Armour Research Foundation, Chicago, helps us prove this point when, before 90,000 people at Soldiers Field, Chicago, on Saturday evening, August 18, he was acclaimed the best male contestant in the Chicago Music Festival. The festival judges who awarded this distinction to Mr. Dalton included: Gladys Swarthout, Lawrence Tibbett and Edith Mason. Mr. Dalton had previously won the bass-baritone division for Cook County, Ill., to enter the Chicago Music Festival.

The "singing foundryman" has been an A.F.A. member since 1937 and is enrolled in the Chicago chapter. He has been a molder, metallurgist and equipment demonstrator in Chicago.

"AMERICAN FOUNDRYMAN"
Advertising Policy to Continue

THAT the AMERICAN FOUNDRYMAN will continue to be published in its present form was assured by a decision of the Executive Committee of the Board of Directors at a meeting held September 5. With National President F. J. Walls presiding, the Committee unanimously recommended suspension of the quarterly TRANSACTIONS and directed the continuation of advertising beyond 1945.

Members of A.F.A. will recall that prior to May 1945, the AMERICAN FOUNDRYMAN was published without advertising, and that papers and discussions presented at the annual meetings were published in a quarterly TRANSACTIONS. The cancelation of the Detroit Convention made necessary a revision of this publication schedule, in order to bring to the membership a continuous volume of valuable technical and practical material.

Accordingly, the Board of Directors voted last January to increase the size and scope of AMERICAN FOUNDRYMAN, effective with the May 1945 issue, under an emergency program of activities. It was unanimously voted at that time to accept advertising in monthly issues of the magazine, in the belief that the increased scope and importance of the publication would perform a real service for both members and the equipment and supply companies.

The judgment of the Board has since been proved through complete acceptance by the membership and increased calls for advertising space by those whose products serve the castings industry.

The Executive Committee's action of September 15 thus guarantees the continuation of advertising in the AMERICAN FOUNDRYMAN beyond the emergency period of 1945, their decision being reached on the basis of four months' experience and following careful analysis of the reactions of both advertisers and readers. Thus the Association will begin its 50th Anniversary year with the AMERICAN FOUNDRYMAN as an established and recognized member of the industrial press. Every effort will be made to maintain its editorial standards and, at the same time, to constantly improve the value of the publication to the Association membership and thus also to the manufacturers and suppliers of foundry equipment and materials.

As the magazine develops, its policies will be determined in large part by a Committee on AMERICAN FOUNDRYMAN Policy of the Board, of which W. B. Wallis, Pittsburgh Lectromelt Furnace Corp., Pittsburgh, Pa., is chairman. Other members of the committee are: H. H. Judson, superintendent, Goulds Pumps, Inc., Seneca Falls, N. Y.; Max Kuniansky, vice-president and general manager, Lynchburg Foundry Co., Lynchburg, Va.; Harry Reitinger, Emerson Engineers, New York; and D. P. Forbes, president, Gunite Foundries Corp., Rockford, Ill.

Herbert Scobie Added To Association Staff

AMERICAN Foundrymen's Association is pleased to announce that Herbert F. Scobie, foundry instructor at the University of Minnesota, Minneapolis, since 1938, has now joined the National Headquarters staff to assist in the coordination and development of the Association's broader program along educational lines. Mr. Scobie, one of the younger and enthusiastic members of the Twin City chapter, joins the organization at a time when the entire foundry industry is especially concerned with its future supply of trained manpower. He will be working closely in conjunction with the Committee on Cooperation with Engineering Schools and Colleges.

Mr. Scobie attended Gustavus Adolphus College, St. Peter, Minn., in 1930-31, then entered the University of Minnesota, school of chemistry, obtaining his degree in chemistry in 1935. Later he received a master's degree in metallography. Prior to becoming connected with the University of Minnesota, he spent several years in industry as a chemist, and while an instructor in foundry practice played an active part in interesting engineering students in foundry work.

He has been an energetic supporter of the Twin City chapter since its founding in 1941, making a wide circle of friends in the Twin City foundry area. As Chairman of the Chapter's Publicity Committee this year, he has edited a very interesting chapter house organ called *"The Shakeout."*

Mr. Scobie organized and is Chairman of a Committee on Chemical Analysis, formed by a group of interested individuals in the Twin City area. He has addressed a number of technical organizations in the Twin Cities, has been active at several A.F.A. Conventions, and is a member of the Committee on Grading and Fineness, Foundry Sand Research Project.

H. F. Scobie

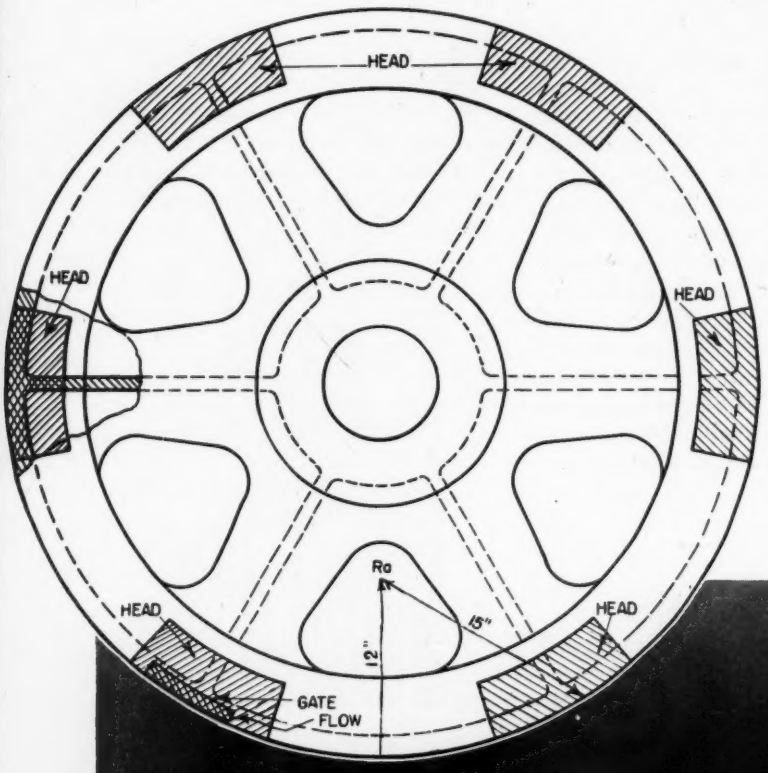
Formation of the Youth Encouragement Committee of the Association's board last fall, coupled with increased activities along educational lines, made necessary a broadening of the National Office staff to carry this work forward. Through cooperation with educators and foundry executives, it is expected that Mr. Scobie will add greatly to the National and local chapter activities of A.F.A. in promoting the interests of the foundry industry among young men of all ages.

Ohio Foundry Five Time "E" Winner

THE Hamilton Foundry & Machine Co., Hamilton, Ohio, has been awarded the Army-Navy "E" award for the fifth time.

The Advantages and Limitations of GAMMA-RAY RADIOGRAPHY on SMALL STEEL CASTINGS

Fig. 1—Sketch showing conventional molding method for blank gear casting—open riser at each spoke junction and bottom gate. Fig. 2—Radiograph of rim section at a spoke junction shown in Fig. 1.



THE use of gamma-ray radiography as a tool for non-destructive testing in the small steel foundry is becoming more prevalent. It is a new process and has reached its present volume primarily because of war production demands. Previous to that time it had been viewed with fear and skepticism, even to the point where some producers refused to consider it.

A few foresighted foundry executives early recognized its possibilities and, when it became a necessity in the

• Improved methods of application and better understanding of interpretation standards have resulted in wide acceptance of radiography as an inspection tool and as a means of developing techniques to assure perfection of castings.

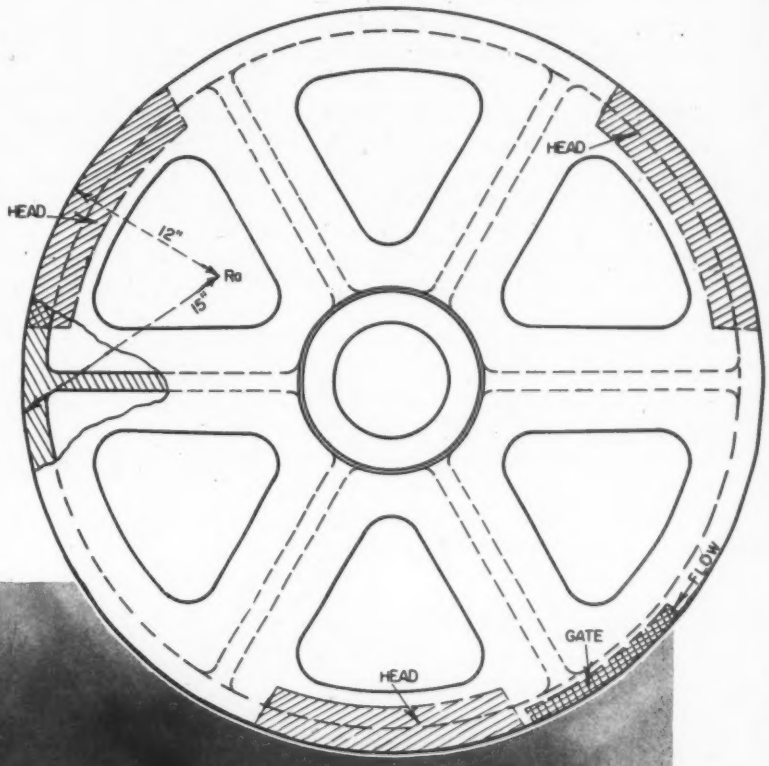
By R. H. Frank,
Chief Metallurgist, Bonney-Floyd Co.,
Columbus, Ohio

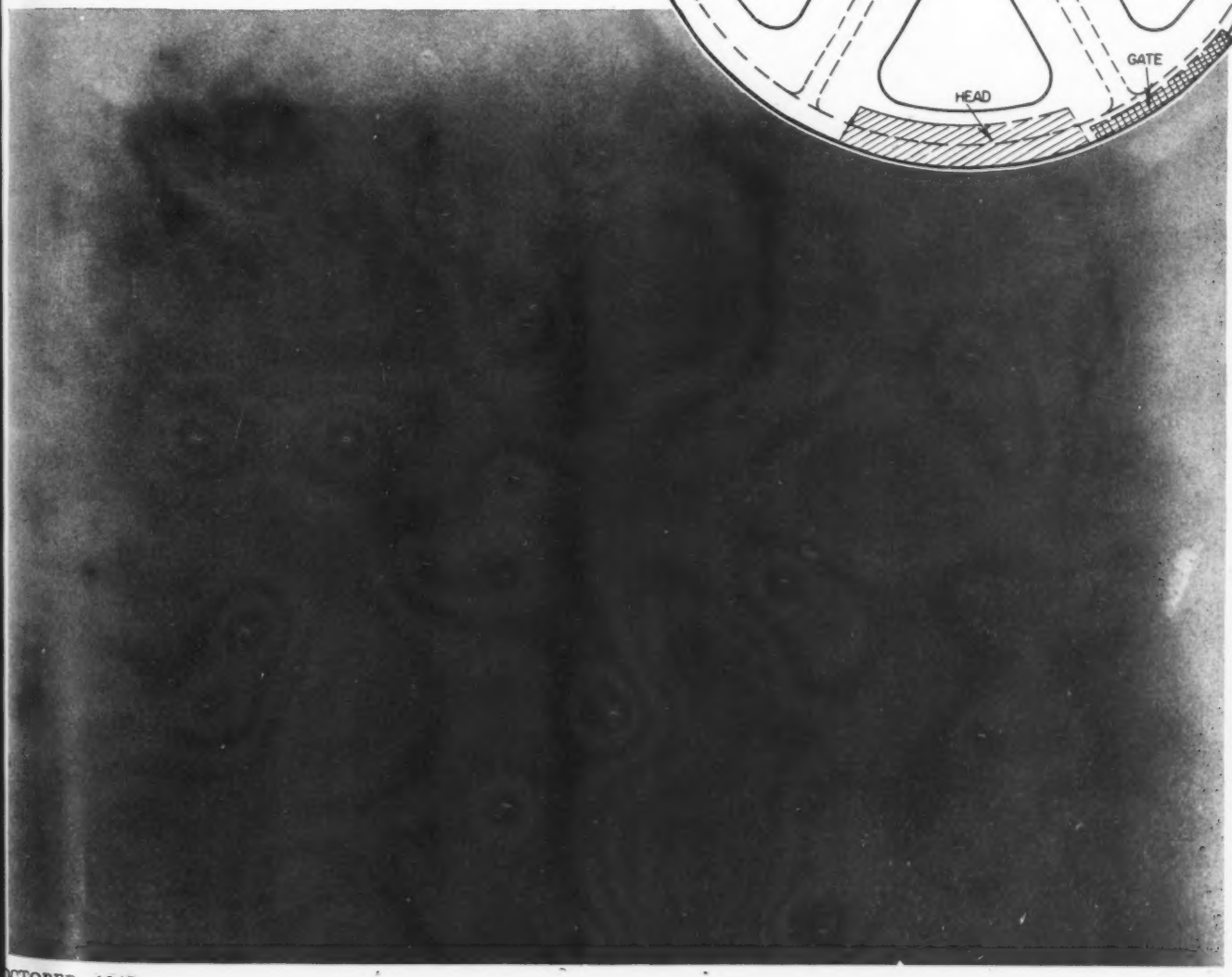
production of certain types of castings, were well paid for the knowledge their personnel had gained in previous years, not only from the standpoint of having experienced radiographers in their organization but also in its use and interpretations for foundry technique.

Slow acceptance of gamma-ray radiography in the industry is not altogether due to the foundries themselves. The promulgators of the process endeavored to introduce their technique too fast and in, so doing, as is the American way when one is told he must do something, they received very little encouragement.

The main source of the objections, disregarding the cost, was in the interpretation of the shadow markings. Who was to say what a certain image on the film was

Fig. 3—Same casting shown in Fig. 1 but with three large risers placed between spokes. Fig. 4—Severe shrinkage shown in gate section of gear casting gated as shown in Fig. 3.





and what it meant, that is, as far as the serviceability of the castings was concerned? There were no standards for comparison and comparatively few persons who could intelligently interpret the images. Analogous to the early situation in radiography is the recent attempt to introduce magnetic particle testing into the foundries without a sound basis of interpretation and customer requirements.

While the names of Mehl, Barrett and Doan are associated with the early developments in gamma-ray radiography, the work of Briggs and Gezelius[1] probably had more to do with the introduction of this process in the foundry industry than any other. Their publication was the first discussion dealing entirely with steel castings.

Later in the same year these authors, in a private publication from the Naval Research Laboratory entitled "Instructions for Radiography with Radium," gave the industry its first working knowledge for the use of radium. Their basic instructions are still used, but in the intervening years many others have contributed improvements and advancements. Both the Army and Navy have issued radiographic standards for the inspection of steel castings, and the ASTM through Committee E7 has published "Tentative Methods of Radiographic Testing of Metal Castings" (E15-39T).

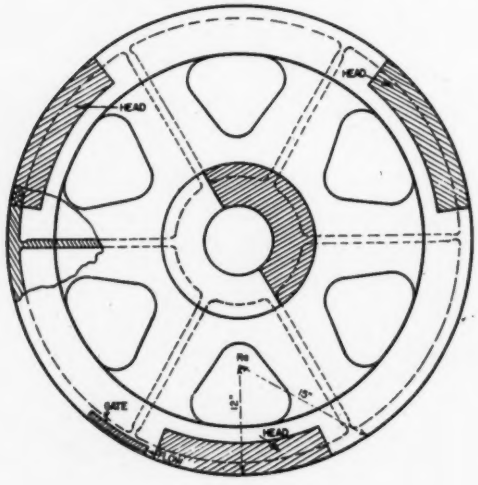
Radiography, like all other testing methods, is not foolproof; it has its limitations and no one can say that it is 100 per cent correct. However, if one is to achieve the best results it is necessary to be thoroughly acquainted with the technique, with strict adherence to details and interpretation.

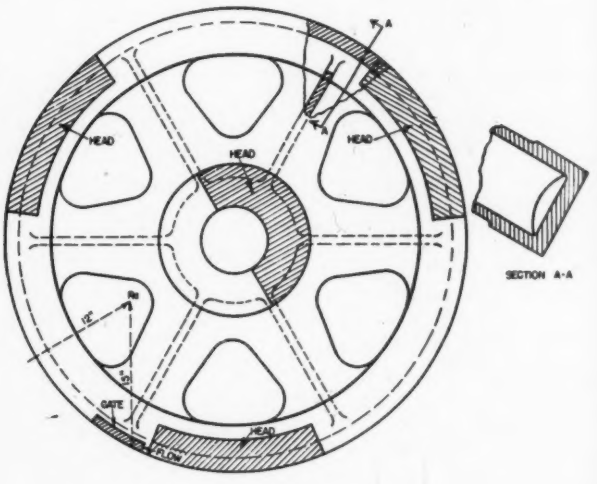
It is not within the scope of this discussion nor is it the intention to elucidate in detail the accepted technique for the making of gamma-ray radiographs. These requirements have been fully explained by Briggs and Gezelius,[1, 2, 6] Mehl,[3] Doan and Young,[4, 5] Woods,[7] Morrison and Nodwell,[8] Taylor,[9] Radium Chemical Co.,[10] and others.

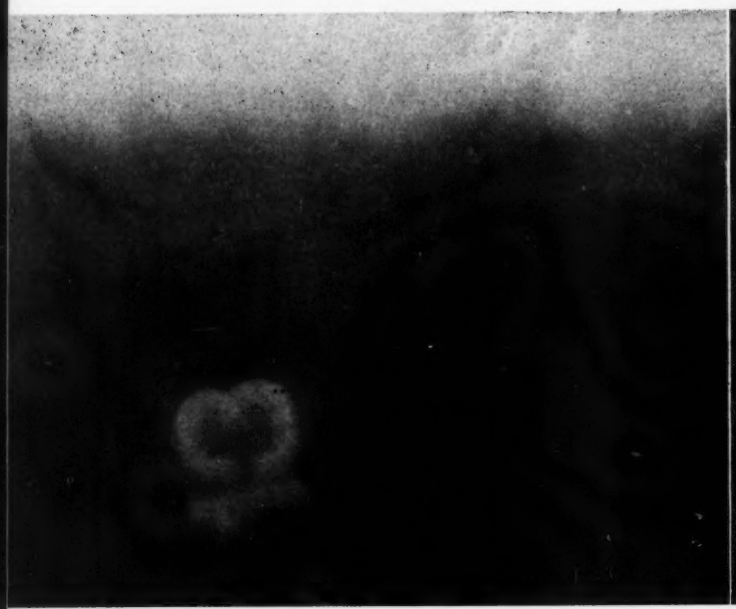
As previously mentioned, interpretation seems to be the main source of contention between consumer and producer inspectors, even by reference to a set of standards. This

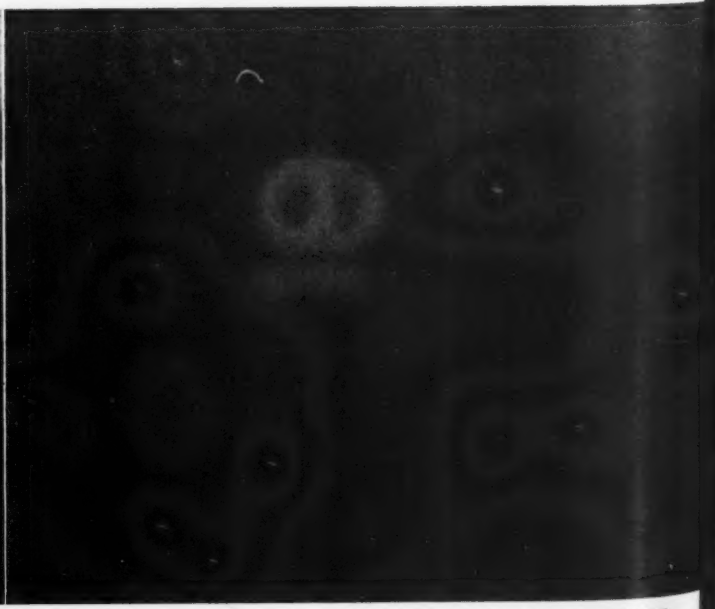
Fig. 5—Casting with risers same as in Fig. 3 but with reduced section at rim junction. Fig. 6 (below left)—Shrinkage in gate section of casting shown in Fig. 5 due to insufficient feeding.

Fig. 7—Drawing of gear casting showing change in design to overcome shrinkage. Fig. 8 (below right)—Radiograph showing that shrinkage has been eliminated in rim section at former intersection (Fig. 7).









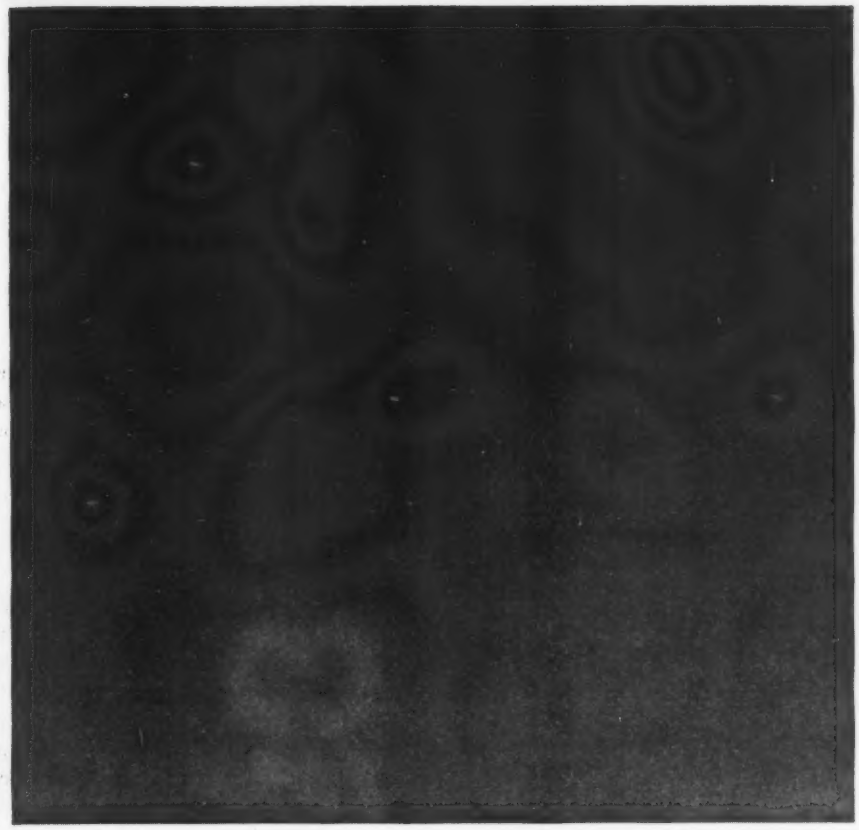


Fig. 9—Considerable shrinkage still present in gate section (see Figs. 7 and 8).

situation is natural and is to be expected, but it is doubtful if any serious disagreement would arise which could not be settled with satisfaction to both parties.

From the author's experience, most difficulties at the start arose within the shop personnel. Many times the skeptics had to be shown by dissecting the casting or carefully chipping the area, as shown on the film, so that the defect was revealed. However, it was not long before even the most doubtful were convinced of the value of radiography for the production of better castings.

At the present time there is a competitive situation between the foundry technicians, several inspectors and the cleaning room foreman as to which castings will be radiographed first, and sometimes it is necessary for the general manager to determine an order of preference.

Again, it is not the intention to enter into any discussion as to the relative merits of gamma-ray versus x-ray radiography. Both have their place in the industry and are more or less interchangeable. Radium is portable, economical, requires no elaborate machinery, lends itself to batch operation, requires less shielding and has more latitude.

On the other hand, x-rays are much faster and more sensitive, especially in the thinner sections. While the foundry in the future may use both sources, it is believed that radium will continue to be the most popular, except in those cases where it would be possible to use fluoroscopic methods, in which field the x-ray, at the present time, is the only means of supplying the energy.

Originally, radiography was developed as an inspection tool for the ultimate consumer to determine hidden flaws or defects in order to preclude the possibility of service failures. In this way the necessary repairs or rejections could be accomplished before serious damage resulted.

While this is still the practice, many foundries have taken it upon themselves to use radiography as a means to develop technique whereby such defects are eliminated by the examination of pilot castings. It may be mentioned here that the Navy, upon request, will furnish radium to be used for this purpose on their own castings. The availability of a unit is limited to its need for final inspection and is subject to recall without advance notice.

The former method for finding these defects was to destroy the casting by cutting it into small sections and examining these pieces visually. On small castings this was not very difficult and fairly rapid, but there was still no assurance that the part was sound since, unless very thin sections were cut, a flaw could exist between cuts and not appear on the surface, thereby giving a false sense of security. While such flaws as shrinks usually can be suspected in certain areas, they do not always appear in that section due to careless operators or pouring technique.

The cutting of large castings is time consuming, laborious, expensive and a much less secure method than in the case of smaller castings. With radiography the casting does not necessarily have to be destroyed, if defects are found, since in most cases it is possible to repair the affected area and make the necessary changes in heading and gating for subsequent elimination of the defect. If speed is essential, radiographic inspection can even be accomplished before the risers are removed.

Probably the best way to illustrate the use of radiography as a nondestructive method for the development of foundry technique is to cite examples or case histories. The case of a large blank gear will be followed.

Gating and Risering

These blank gears were about 6 ft. in diameter with a 12-in. face. They were designed with six spokes and an open or window-type web, as shown in Fig. 1. The molding method was convential, that is, an open riser at each spoke junction and a bottom gate.

The six risers were considered as necessary due to the heavy metal section at the junction of the spokes with the rim. It is essential that these areas be solid because the bottom of the teeth is about 1 in. below the cast surface, and if there are any shrinkage cavities the teeth will be weakened. With this molding method no shrinkage troubles were encountered.

While the entire rim was radio-

This paper was secured as part of the 1945 "Year-'Round Foundry Congress" and is sponsored by Steel Division, A.F.A.

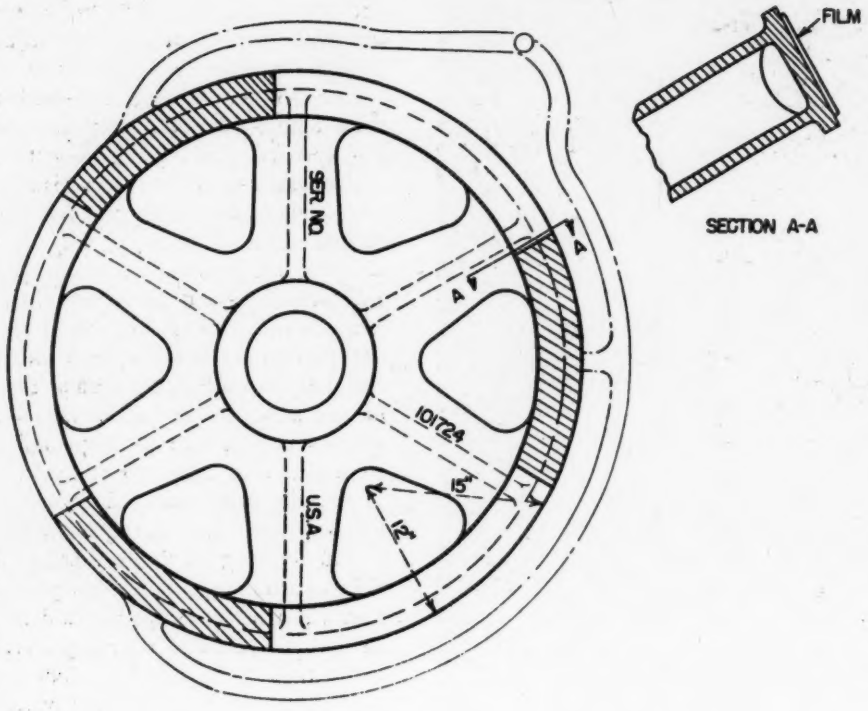


Fig. 10 (above)—View of gear casting showing change in gate position to eliminate shrinkage in gate section of rim. Fig. 11 (below)—Shrinkage in gate section has been overcome by change in gate position (Fig. 10).

graphed, it is not deemed necessary to display all of the films. In this and the following examples the internal structure of the junctions for each set is fairly constant, so one typical example should be sufficient for this purpose. Figure 2 shows one of these sections for this molding method.

In order to increase the yield, the idea was conceived that proper feeding of the spoke junctions could be achieved with three larger risers spaced between the spokes, as shown in Fig. 3, the theory being that one riser would feed two junctions. Radiographic inspection quickly disproved this assumption as severe shrinkage was found at the intersections (Fig. 4).

While this is the radiograph of the gate section and much more shrinkage is shown at the hot spot (top of film) created by the gate, it still is typical of the other intersections. There should be no question but that, considering the service of these gears, this casting is unsatisfactory and even the most lenient foundry-

Fig. 12—Radiograph showing that "tight" plug fitted into wall section of casting was not satisfactory.

Fig. 13—Same section shown in Fig. 12 after plug had been removed and the hole welded.

man would quickly discard this molding method.

It is a well-known procedure among foundrymen that decreasing the metal section at the intersection of two or more ribs will lessen the propensity toward shrinkage in that area since it would be more uniform. Following along these fundamentals, it was suggested that the spokes be constructed at the rim junction, as shown in Fig. 5, and a casting was made according to this design.

Here again the films showed that this reduction in section was insufficient for these risers to properly feed the intersections. Severe shrinkage was found, as shown in Fig. 6. As in the previous example, this is the gate section and shows considerable shrinkage, for reasons explained, but is still symbolic. Needless to say, this method was quickly discarded because of the results obtained in this one casting.

Following along the same line of reasoning as before, the next design change was to divorce the intersections completely except, of course, at the web. In this manner the rim section was made as uniform as possible under the circumstances, as shown in Fig. 7. The radiographs showed (Fig. 8) that the rim at the former intersections was now solid, but that the gate section (Fig. 9) still contained a considerable amount of shrinkage.

Up to this point no one had ques-

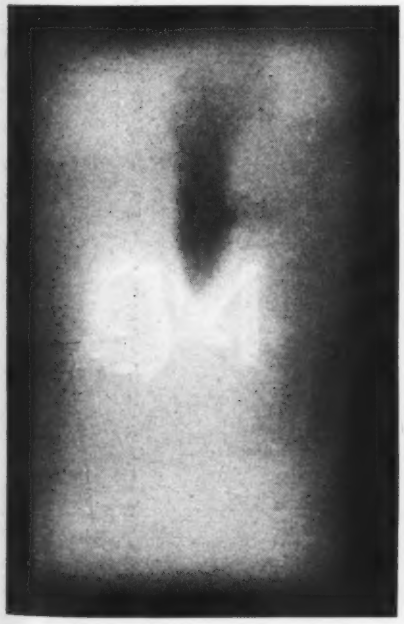


Fig. 14—Shrinkage in large motor shell casting which had two large pole pieces on inside. No riser was used for feeding pole pieces inside of motor shell.

Fig. 15—Unfused chill in same section shown in Fig. 14.

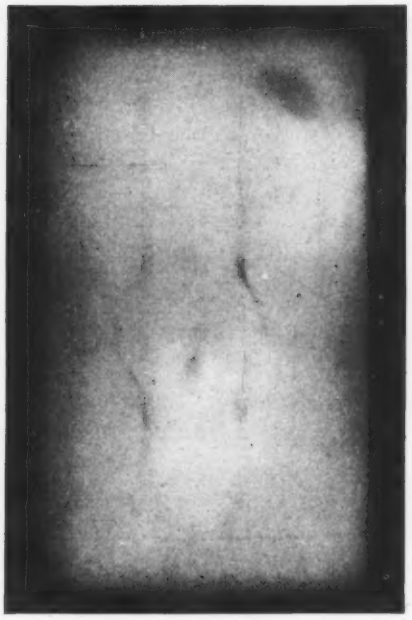


Fig. 16—Use of a pressure riser eliminated shrinkage (Figs. 14 and 15).

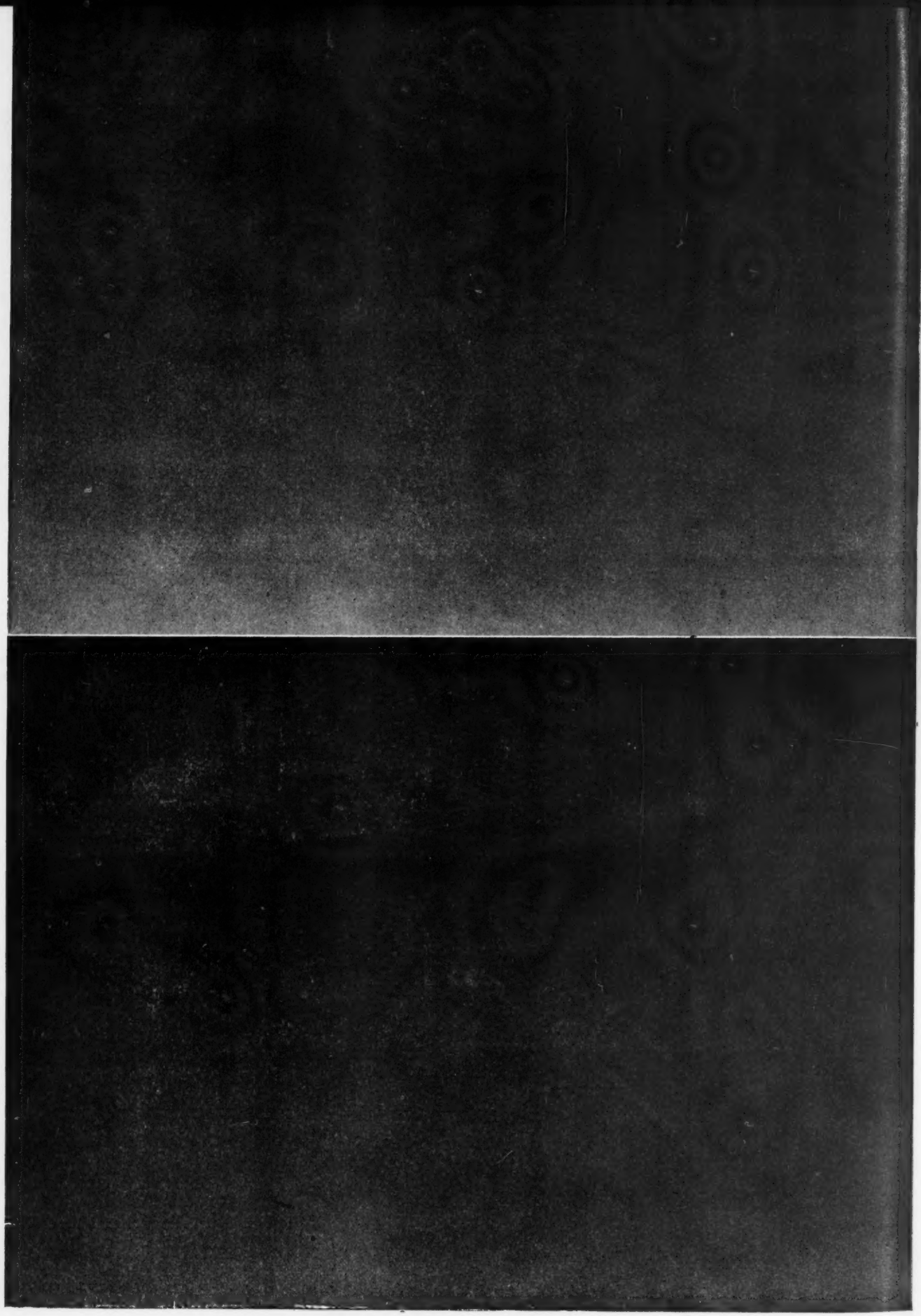


Fig. 17 (top)—Radiograph of ring casting section. No shrinkage present. Overall height, 12 in.
Fig. 18 (bottom)—Ring casting section, overall height, 11½ in. No shrinkage shown in casting proper.

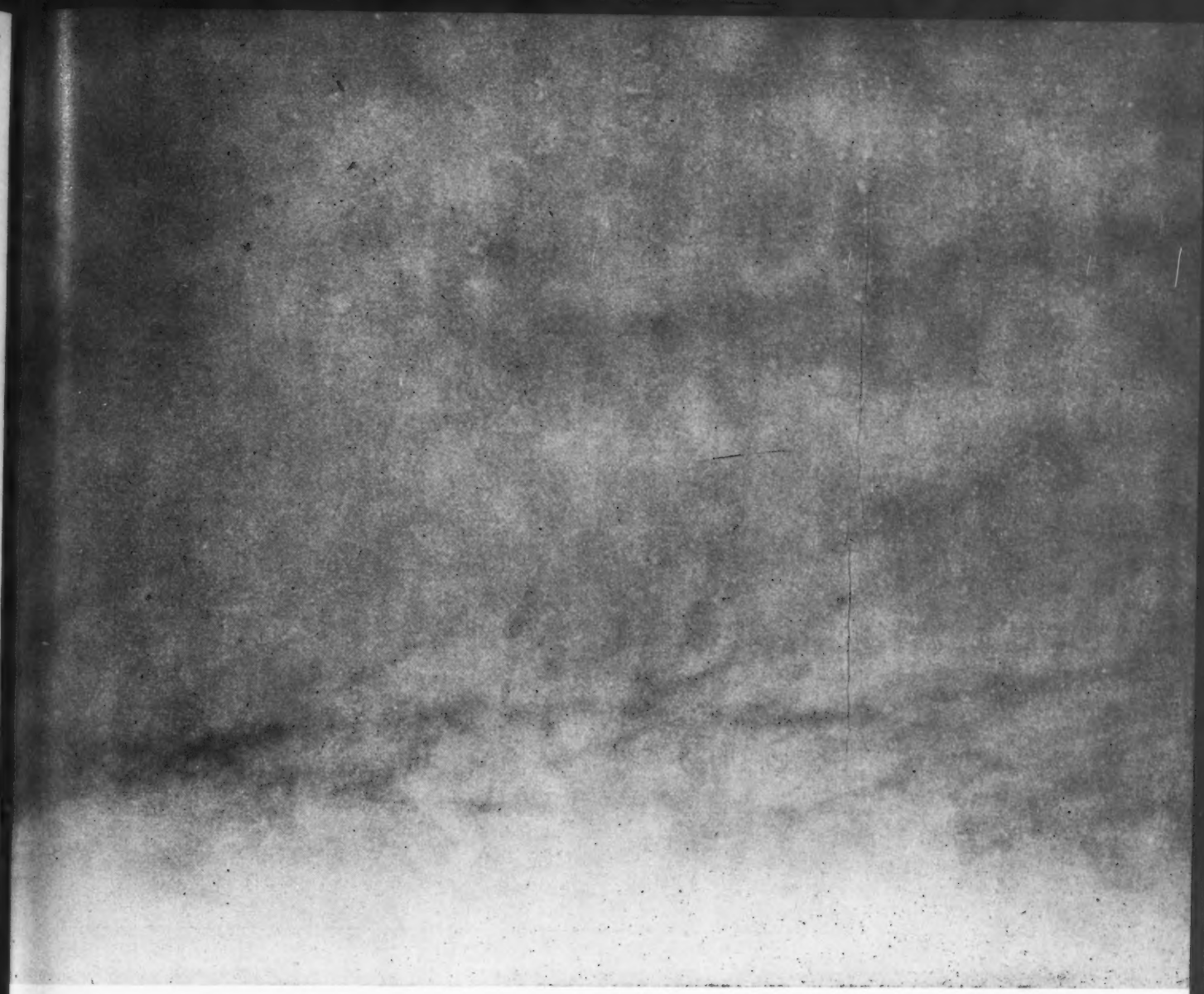


Fig. 19—Another ring casting section, overall height 12 in. Radiograph shows severe shrinkage or hot tears extending far down into casting.

tioned the interpretation of the films. However, when this casting was determined to be solid with the exception of that section near the gate, doubt was loudly expressed by a number of the foundry technicians. While the casting did show a few surface imperfections at this point, the radiographer held to the original interpretations that the shadow markings were internal defects or, in other words, shrinkage.

Proof was established by burning out this section with the carbon arc. This one instance, which happened a number of years ago, was the turning point for the skeptics in this foundry.

The logical step to follow in chronological order was to change the position of the gate, since the original purpose had been realized. This was accomplished by gating into each riser at the joint, as shown in Fig. 10. Because there was no shrinkage in the previous design, except at the gate, none was expected by this method, and this assumption is clearly evidenced by a typical junction, as shown in Fig. 11. Needless to say, this method was then adopted for production.

An interesting application happened several years ago when the foundry was called upon to make a strainer casing for service under high temperature and pressure. Since no core shift could be tolerated, it was thought necessary to hold the large core in place by a heavy rod anchor extending through the cope.

It was known that the anchor would have to be removed and the casting repaired, but the engineers said they could make a threaded plug so tight that it could not be found. After drilling out the anchor rod the hole was threaded and a plug fitted into the center of the wall section, leaving a depression of approximately ¼-in. on each side to be welded.

The radiograph, as shown in Fig. 12, revealed just how tight this "tight" plug fitted. Of course, this could not be permitted, so the plug was removed and the hole welded by placing a backing strip on the inside. The radiograph (Fig. 13) then showed an acceptable and uniform structure. Incidentally, the anchor method was quickly discarded and other means used to hold the core in a central position.

Another pattern was for an enclosed type motor shell which had two large pole pieces on the inside. These were in such a position that it was almost impossible to reach them with an open riser, and in-

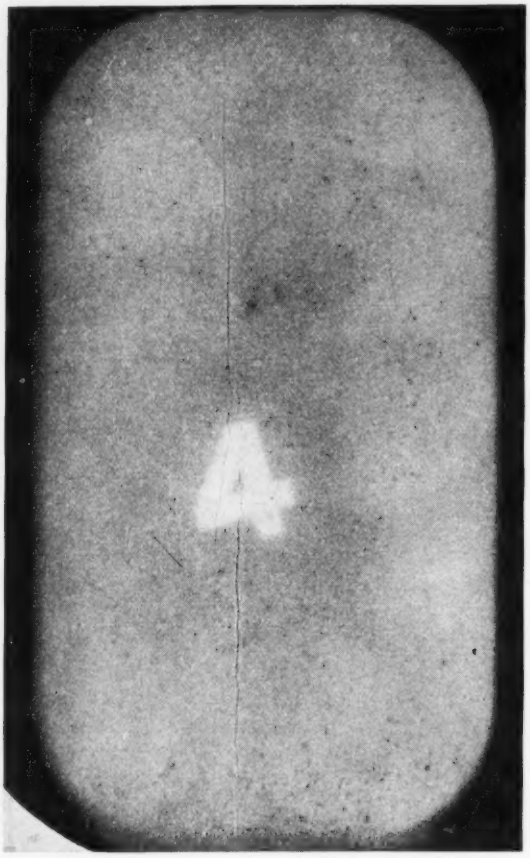


Fig. 20—Example of misleading radiograph. Appearance of pinhole porosity was due to use of faulty film.

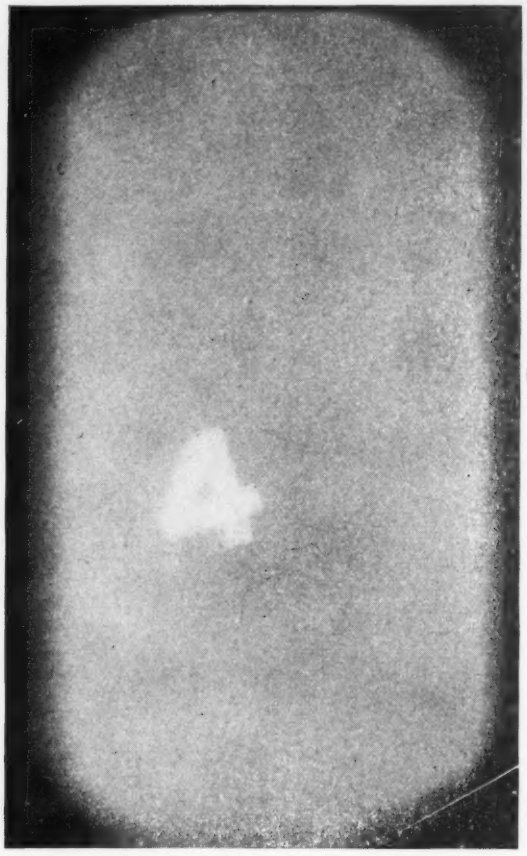


Fig. 21—Another radiograph of same section shown in Fig. 20 shows slight centerline weakness but no porosity.

volved considerable pattern expense and time to provide a blind riser. Since they were fairly large castings and it was not wished to destroy any, it was decided to make two molds, one without any feeding at the pole pieces and one with an internal chill.

The radiographs, Figs. 14 and 15 respectively, determined that neither method would be satisfactory since, as was expected, the one showed a large shrink and the other the unfused chill. There was then only one method left, and that was to provide a pressure riser. Figure 16 shows that this should have been done in the first place, regardless of time and expense.

Even after the radiograph reveals the presence of internal defects it is not always possible to immediately diagnose the trouble so that a subsequent occurrence will be prevented. A ring casting of 36-in. diameter, 3¼-in. thickness and 6-in. height had been in production for some time without any shrinkage troubles being experienced.

It was designed with an open ring riser bottom gate and the mold filled from the gate, i.e., no metal was poured into the riser. Not long ago three of these rings were cast in the same heat and, as far as could be ascertained, all had been poured in a conventional manner. Since these castings are shipped to the customer without removing the riser, they of course are inspected with the riser attached to the casting.

An alert inspector noticed that the shrinkage cavities in one of the risers looked deeper than in the others. Visual inspection and inserting wires seldom give the true depth of these cavities. Furthermore, since the customer removed the riser, the foundry did not wish to deliver a defective casting, so it was decided that the quickest and least expensive method to determine the depth of the shrinkage was to radiograph these castings.

As in previous examples, it is not deemed necessary to exhibit all of the films, so only one radiograph on each casting will be used to demonstrate the problem. The first ring, with an overall height of 12 in. from the bottom of the casting to the top of the riser, did not have any shrinkage in the casting proper, as is shown in Fig. 17. The second ring, as is shown in Fig. 18, while it showed no shrinkage had an overall height of only 11½ in.

The third ring, with an overall height of 12 in. (Fig. 19), exhibited

Written discussions of this paper are solicited for publication in future issues of "American Foundryman" and/or bound volume of "Transactions." Discussions should be sent to Secretary, A.F.A., 222 West Adams St., Chicago 6.

severe shrinkage or hot tears which extended far down into the casting. While the cause of this anomaly is still being discussed, with no logical answer as yet forthcoming, it certainly demonstrates the use of radiography for maintaining a supplier's integrity.

Sometimes the interpreter may be misled by his own films unless he is very careful, as in the following case. A light, cup-shaped casting with four protruding feet was radiographed to determine the solidity at the junction. One of the feet, as shown in Fig. 20, was interpreted at first as showing fine pinhole porosity, but the others were clear.

The foot itself occupies only the light rectangular portion of the film. There being some question as to the cause of the porosity in one foot and not the others, the film was again placed on the viewing box. This time, possibly because the rheostat was turned higher, thereby increasing the light-intensity, the same type of shadow markings was observed on the film in the area outside of the casting or, so to speak, in the air.

Another radiograph was taken immediately (Fig. 21), which showed nothing but a slight center-line weakness. The only difference between the two radiographs was the film, and it had been taken from the same box. No satisfactory explanation has as yet been found, even after submitting the films to the manufacturer.

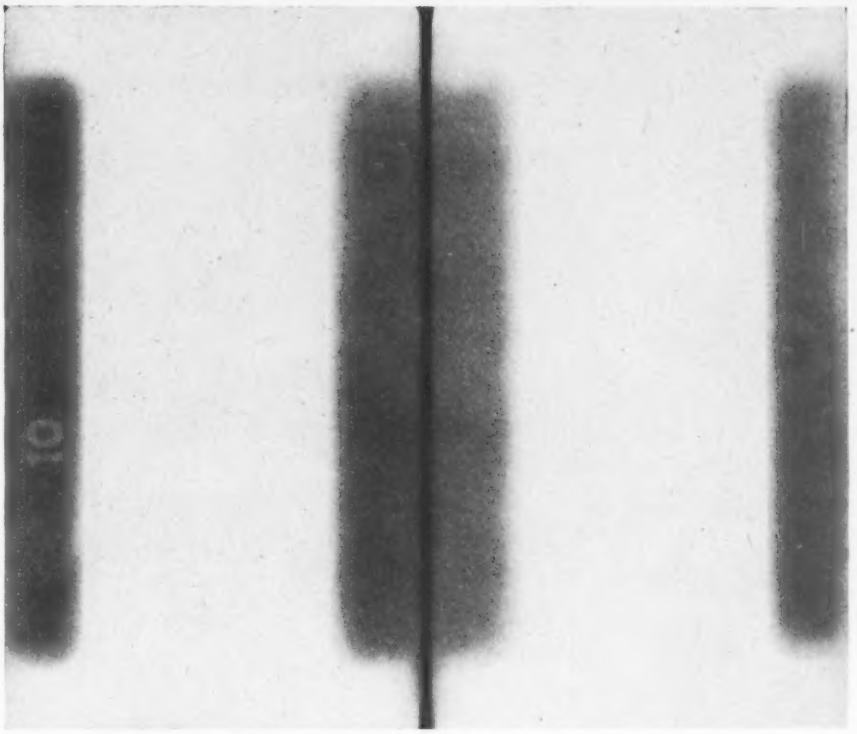


Fig. 23—Same section shown in Fig. 22 appears very clearly on "Type A" film under conditions of strong illumination.

This illustration is given only to serve as a warning to the observer so that he will not be too hasty in his interpretation of the shadow markings. It might also be mentioned at this point that it is good policy to mark the surface imperfections with small arrows before exposing the film. This partially eliminates controversy as to whether a shadow marking is external or internal, and helps immensely in locating internal defects so that they can be marked on the surface for subsequent removal and repair.

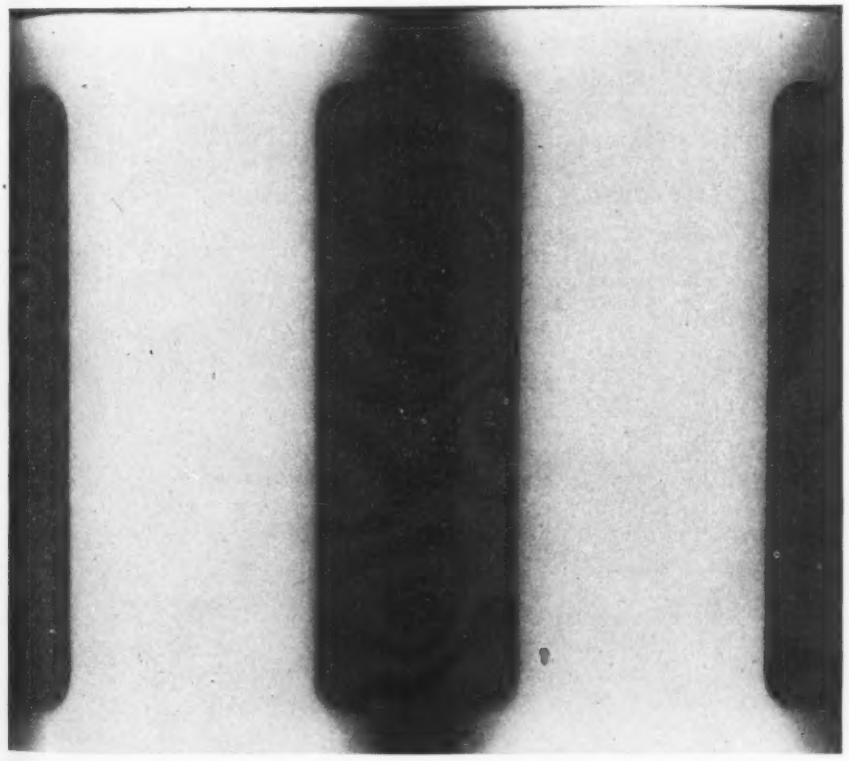


Fig. 22—Example of method using two films of different speeds in the same holder. Film density for ¾-in section when exposed for 2⅜-in. section is entirely too high for proper interpretation on this "no screen" film.

Exposure Methods

The satisfactory showing of wide variations in thickness by one exposure has always been a problem. The first method used was to expose two films of the same speed in one holder and reduce the exposure time by approximately 40 per cent. The thicker sections were then viewed through the two films superimposed upon each other, and the thinner sections through one film, but the method was not entirely successful.

The high-intensity illuminator with a variac control has been used with considerable success for a number of

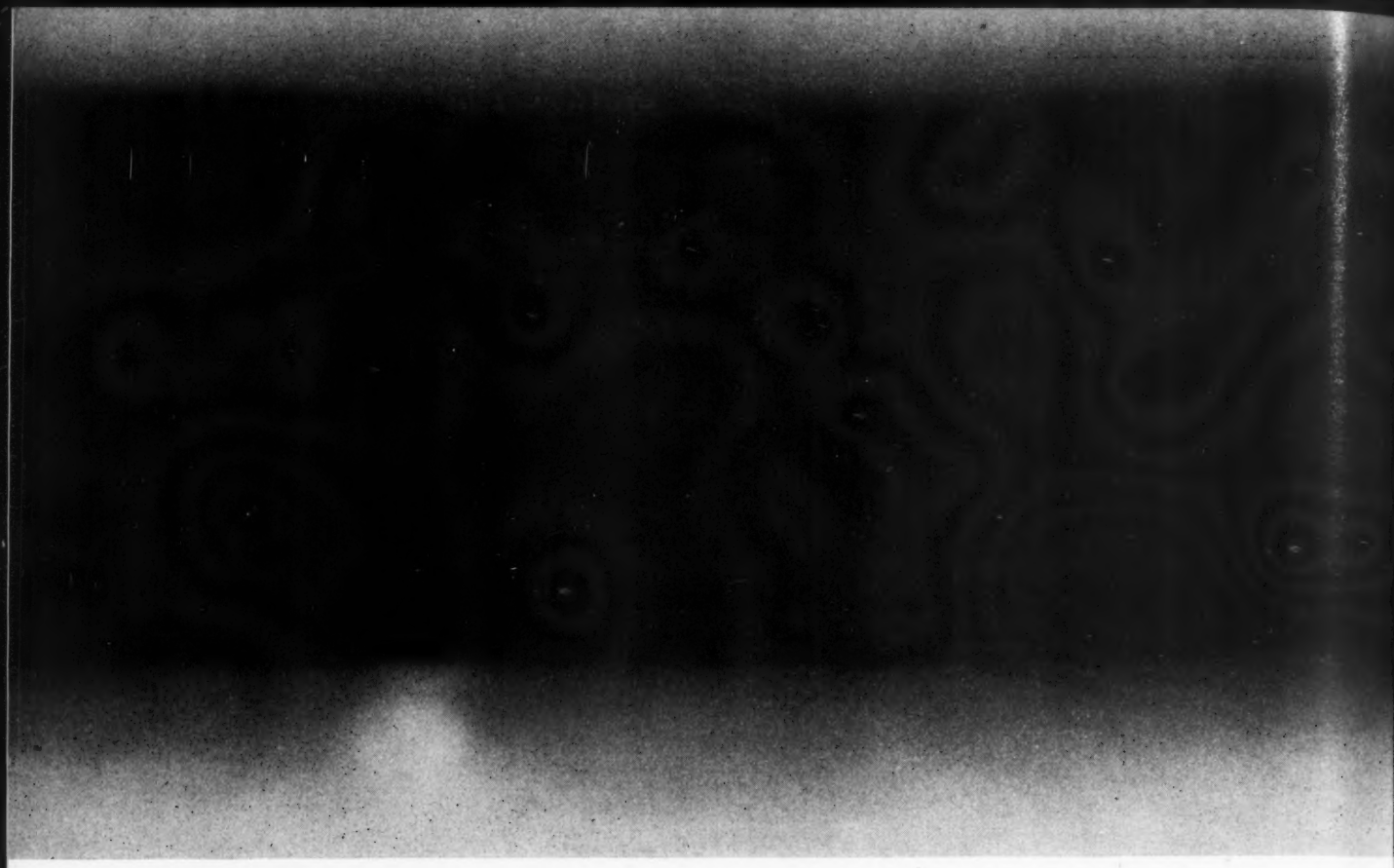


Fig. 24—The double film-different speed method applied to casting section thicknesses of 1¼ in. and 3¾ in. Exposed for the 3¾-in. thickness, only faint differences in density for the thin portion appear on the "no screen" film under strong illumination.

years. With this method only one film is exposed to conform to the greater thickness and the denser portion of the film viewed with the high-intensity illumination. The latest innovation is the use of two films of different speeds in the same holder. We are indebted to Seeman and Corney[11] for the suggestion, to Taylor[9] for the actual development.

By a combination of the last two methods we are able to observe wide variations with one exposure. Figures 22 and 23, using films of different speeds, show a small casting with the thickness ranging from ¾-in. to 2⅜-in. ("no screen" and "Type A" film respectively). The ¾-in. metal, when exposed for a 2⅜-in. section, gives a film density entirely too high for proper interpretation on the "no screen" film but shows very clearly on the "Type A" film.

Since the casting (Fig. 23) showed

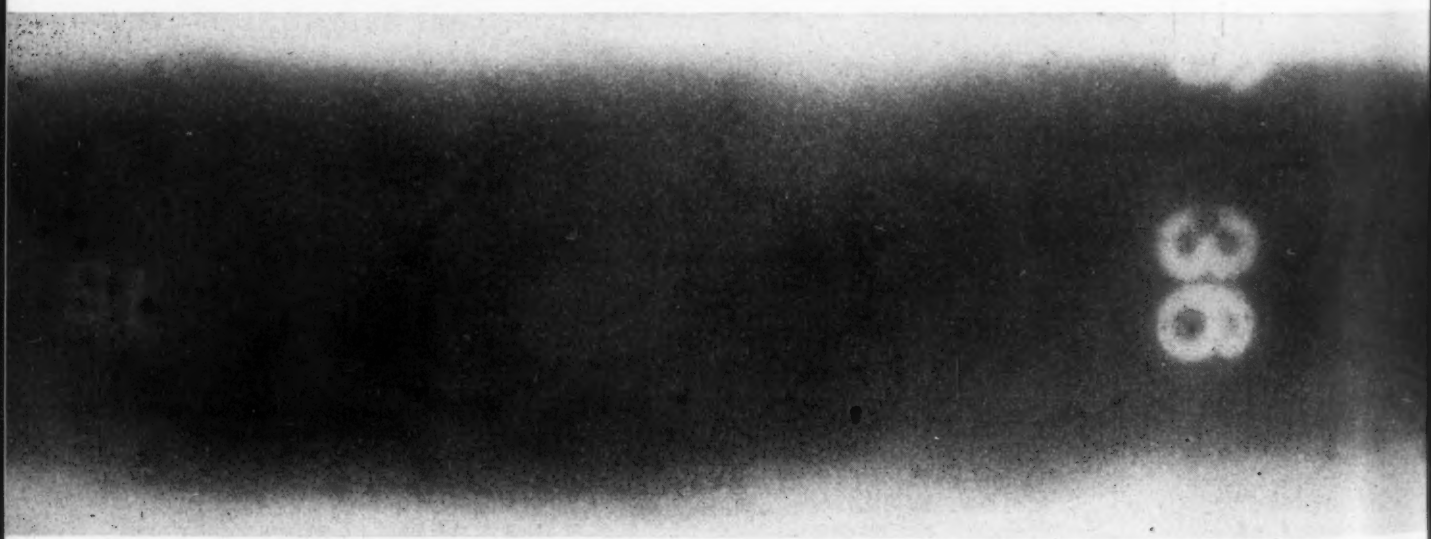


Fig. 25—Gas holes appearing in same section shown in Fig. 24 on "Type A" film under ordinary illuminating conditions.

no internal flaws, probably a better illustration of the double film-different speed method would be one where imperfections were detected in the thinner section. The radiograph of a section of a high pressure turbine casing, coming under Class 2 Navy Standards, is shown in Figs. 24 and 25. The difference in thickness depicted in these two films was 1¼-in. and 3¾-in. and the same types used as before, exposing for the 3¾-in. thickness.

Figure 24 is the "no screen" film, and under the strongest light available, namely, two no. 1 photofloods, only faint differences in density could be observed in the thin portion. Figure 25 is the "Type A" film, and under ordinary light numerous gas holes can be clearly seen. Without this double-film method it would have been necessary to make another exposure for the 1¼-in. section.

While the author has used this method for only a short time, it is believed that it has wide possibilities. There are a number of other combinations of different-speed films that can be used and which it is intended to try. In the last illustration shown there was a difference of 2½ in. between the wall thickness, but it is probable that with the proper films differences of 4 in. can be shown with satisfactory density.

Conclusion

In concluding, it might be said that there are numerous other examples of radiography for the development of foundry technique, not only in this shop but in many other places. The value of this method is clearly evidenced by the few examples cited. Without the use of radiography, the development of these castings would have been time consuming and expensive since it would have necessitated their destruction by sawing or machining for visual examination. It would not only have been dangerous but perhaps have caused a loss of prestige and valuable machining time if these castings had been delivered without examination.

In a certain bureau of the government there is a saying that it is better to protect than detect. This surely can be applied to the foundry industry, since it would be much better for the producer to protect himself by radiographic inspection than to have the imperfection detected by the consumer. Radiography may have been a burden at one time, but it is now a necessity and is here to stay.

Acknowledgment

The author wishes to express his appreciation to R. E. Fisher, President, Bonney-Floyd Co., for his permission to publish this discussion. He is also deeply indebted to Dr. C. H. Lorig, Battelle Memorial Institute, for the preparation of the slides.

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• COMMITTEE REPORT

Cupola Research Project Nears Completed Stage

By Chairman R. G. McElwee, Vanadium Corp. of America, Detroit

PREVIOUS reports have covered the aims and purposes of the Cupola Research Project Committee, but for the benefit of all, the main objective may be summarized briefly as to establish a much needed research project to cover those phases of cupola melting concerning which adequate data are not available in the literature. To accomplish this objective, the Cupola Research Project Committee decided on the following steps: (1) Review of the literature on cupola operation to determine what data are available; (2) Evaluate and correlate this, plus unpublished information on cupola practice; (3) Compile a Cupola Operator's Manual from the work done on (2). This work will show the "blind spots" in available data; and (4) Attack the "blind spots" by a well-directed research under the sponsorship of the Technical Development Program of A.F.A.

The literature review has been completed by Battelle Memorial Institute, Columbus, Ohio, as a joint project between the institute and the committee. Assignments for preparation of various sections of the book were made to subcommittees whose personnel was chosen carefully on a basis of experience and authority. The literature review has been of considerable assistance to these subcommittees in the preparation of text for the manual. Over two-thirds of the chapters have gone to the technical office for arrangement and final editing and the remainder, which are in the process of final "dressing up," will be ready in a very short time.

The assembling of chapters and the make-up and indexing of the book are still ahead but in capable hands, and the result should be a manual containing helpful material for everyone operating a cupola. With the publication of the manual, all work preliminary to the actual research will have been completed. From there, the real job of research will start. Those items will be selected for investigation which experience has shown to be least satisfactorily covered in the literature.

Fig. 1 (Right)—High school cooperative student determining manganese content in steel samples.

Fig. 2 (Below)—Trainee determining tensile strength of steel sample.

Fig. 3 (Bottom, right) — Molding sand strength determination.

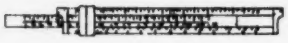
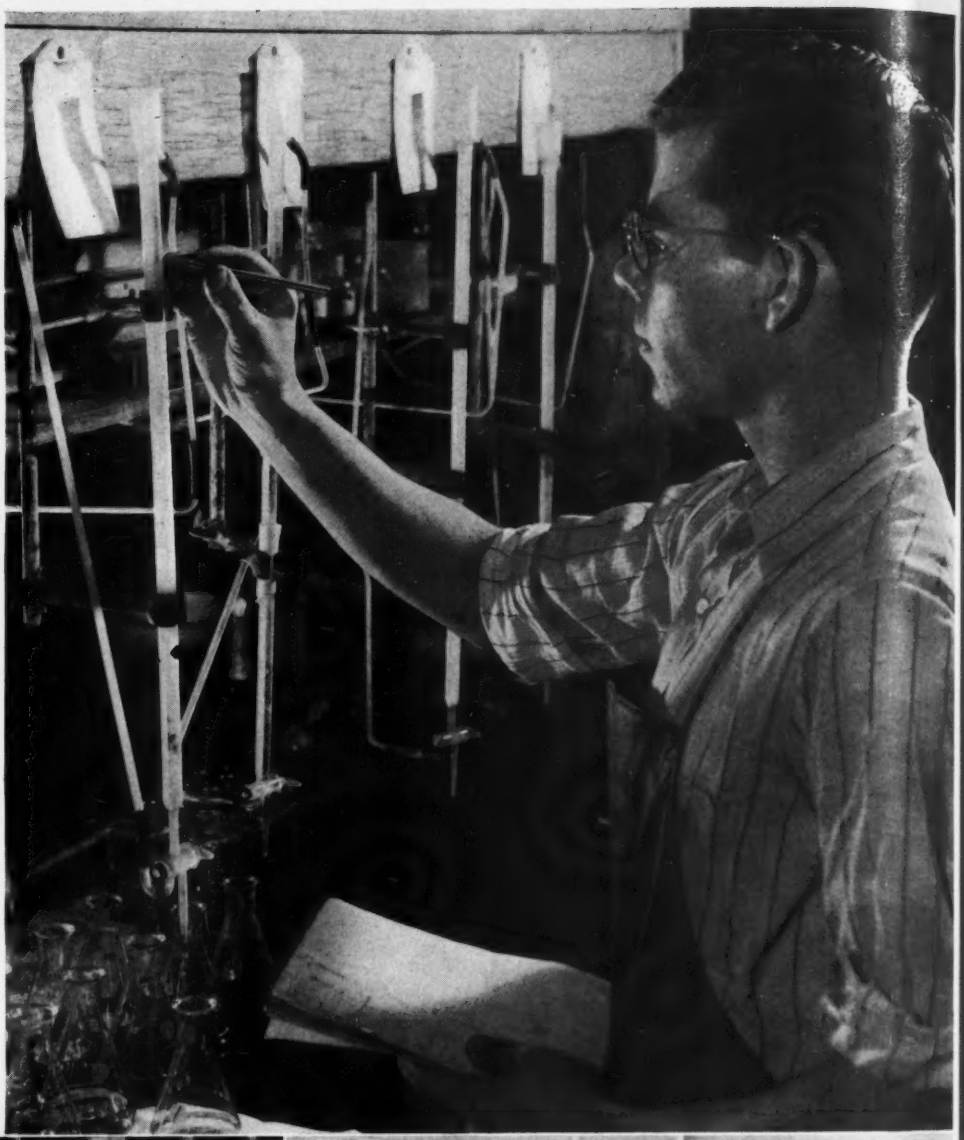


Fig. 4 (Opposite page, left)—Students solving applied problems in study of slide rule. Fig. 5 (Opposite page, right)—Study of track-type tractor transmission during shop trip.



CATERPILLAR COOPERATES

in Training High School Students for Foundry Work

• Cooperative training programs, properly organized and conducted, have proved their value—providing a source of trained personnel for industry and enabling the young student to establish an early contact with the working world—satisfying himself that his choice of a career is the proper one.

By Paul Griebel,
Training Department, Caterpillar Tractor Co.,
Peoria, Ill.

APPROXIMATELY one year ago, the company with which the author is associated established a cooperative training program in conjunction with four local high schools. The purpose of this plan is to provide an opportunity for qualified high school students to gain work experience in industrial laboratories, thereby applying the theoretical knowledge of physics and chemistry learned in high school to practical physical testing and chemical analysis in industry.

The proved success of the plan in the laboratories suggested expansion to other fields. Consequently, the program now includes a second group working in the engineering department as tracers or drafting students. For the sake of brevity, this article deals only with the laboratory program.

The success of the plan has been due to the care exercised in presenting its opportunities to the prospective trainee, his selection and training, coordination of his plant and school work and strict adherence to the agreement reached between the school authorities and the plant in regard to the student, plus the fact that the coordination rests with the school authorities.

Selection. Each year, the cooperative training program is presented to an assembly of high school juniors a few weeks before the close of the school year in June. All students interested in the program are invited to the plant, where screening tests are given and they are individually interviewed.

A list of qualified students is prepared on the basis of the tests and interviews, and this list is discussed with the high school physics and chemistry teachers as well as the deans. At this conference, final selection of the applicants is made. The cooperation of high school staff personnel is invaluable, since they are far better acquainted with the abilities and characters of the students than the interviewer could possibly become in his brief meeting with applicants.

Students selected for the program are offered summer employment as laborers in the plant. The work con-

sists mainly of material moving where they have the opportunity of handling many types of forgings and castings. This acquaints them with the surroundings and gains them valuable experience in recognizing specific parts. While summer work at the plant is not prerequisite to participating, its merits are obvious.

At the start of the fall school term, the students are transferred to the particular laboratory in which they begin their cooperative work. They spend approximately 4 hours a day on the job, which merits high school credit, while carrying enough subjects at school to assure graduation.

Schedules are arranged so that half of the participating students work in the morning and half in the afternoon. In this way, the eight available openings in the laboratory are filled by 16 students, each working one-half day.

Type of Work. At present three laboratories participate in the program; namely, metallurgical research, metallurgical control, and foundry metallurgical laboratories. Types of work with which the student becomes familiar depend, of course, on the particular laboratory in which he works. A brief description of the work available in each laboratory follows.

Outline of Student's Work

The metallurgical research laboratory has work available in two divisions, (1) the analytical laboratory and (2) the physical chemistry laboratory. The trainee works in both divisions, becoming familiar with the common methods of material testing, various electro-plating processes, evaluating effectiveness of corrosion inhibitors, resinous paints and testing plastics.

Since some research in fuels and lubricants also is carried on in this laboratory, the trainee learns how to conduct viscosity, acidity, carbon residue, and flash point investigations.

In the metallurgical control laboratory, the trainee works in the sample cutting division, chemical laboratory, and physical test division (Figs. 1 and 2). All students thus are able to prepare test specimens from mill heats and follow them through the various test procedures. Work experience in the foundry sand control laboratory (Fig. 3) includes analyses of both molding and core sands. These tests are for permeability, compressive strength, moisture content and green and dry tensile strength. The trainee obtains his own samples from the molding floor, affording him the opportunity of becoming familiar with the foundry.

The trainee's work in the chemistry division of the foundry laboratory consists, in part, of preparing materials for analysis. He also is given instruction in the procedures followed in determining carbon, sulphur, silicon, manganese, molybdenum, chromium, and nickel content in cast irons.

Various core oils, clays, and binders are purchased by the foundry on specifications, and these materials are tested before they are used. The student receives instructions in the procedures for making these tests.

Training Stations

It will be noted that each laboratory has several training "stations." A student employed in the research laboratory will spend part of his time in the analytical division, part in the physical chemistry division and some time in the foundry laboratory.

Each student employed in the tractor metallurgical laboratory will divide his time (not necessarily equally) between sample cutting, physical testing, chemical testing, and the foundry laboratory.

Note that the foundry laboratory is a "station" for all students. This affords each participant the opportunity of becoming acquainted with gray iron foundry practice and the required laboratory control.

Instructing the Student

Method of Instruction. The student is instructed in various tests and procedures by his supervisor. He then works for a period of time with a regular employee, until he has gained the manual dexterity required to handle the particular job. At this point he has the responsibility of performing the task in the proper manner. Occasionally "blind" tests are run in chemical analyses to check the accuracy of the trainee's work.

Classwork. In addition to the classes taken at the high school, all participants spend 2 hours of their Saturday work time in class at the plant (Fig. 4). Classwork consists of discussions on company organization, industrial economics, study of the gasoline and diesel engines, as well as company products in general, operation of the slide rule, fundamentals of heat treatment and metallurgy, and blueprint reading.

Oral instruction is supplemented by use of cut-away models of products, motion pictures, and shop trips for the purpose of viewing assembly, heat treatment, and foundry operation (Fig. 5).

Trainees are paid the regular training rate while attending class.

Duration of Course

Students participating in the program are not under written contract. However, some points of verbal agreement are:

A. Employment under this agreement will be limited to high school seniors and will begin during the first school week of the fall semester.

B. Training under this agreement will be discontinued if the student discontinues his high school education.

C. Following high school graduation, one of five possible actions is considered:

1. The student, if he measures up to the department's requirements and so desires, and if an opening is available, can be transferred to the regular staff of the laboratory.
2. The student will be eligible for all three of the company's apprentice courses: foundryman, patternmaker, and machinist. He can compete for enrollment in any one of these courses.
3. The student may take the examinations for a cooperative course at Illinois Institute of Technology or other near-by college.
4. He may transfer to work of another type, if an opening is available and he can qualify.
5. He may resign.

Credit. Students participating in this program receive one full unit of high school credit per semester, i.e., two full credits per school year. Both credits are acceptable toward high school graduation and one is recognized by the University of Illinois for college entrance.

Program Coordination

Coordination of the cooperative program rests with the high schools and is handled by a coordinator appointed by the public school of-

(Concluded on Page 72)

Sand Control in a
MALLEABLE IRON FOUNDRY

• This paper on malleable foundry sand control is one of several being prepared at the request of the Malleable Division Program Committee, which is planning to continue the yearly symposia on malleable foundry practice started several years ago. These papers on this subject will later be incorporated in a reprint on malleable sand control as the Division's contribution to the 1945 program. Included in this symposium will be the summary of some 14 companies' answers to a questionnaire on malleable sand control.

The ultimate objective of the Division is to later incorporate all of these symposia in a book on malleable foundry practice. Previous symposia covered (1) Graphitization of White Cast Iron, (2) Malleable Iron Melting, and (3) Gating and Heading.

By Gordon Davis, Assistant Superintendent,
Malleable Foundry, McCormick Works,
International Harvester Co., Chicago

PROPER molding sand in a malleable foundry is one of the most important items in the production of good castings. For various types of castings, satisfactory and consistent production is almost impossible without a sand control standard.

Sand control becomes a necessity because of inspection requirements of high quality finish, and in the interests of cost reduction to eliminate finishing operations on rough castings and to simplify sand control for individual molders.

Work which has been done to develop and perfect sand testing has really taken a burden from the foundryman's mind by helping in the elimination of superficial cracks, internal shrinkage, etc. It has resulted in improved cleaning methods and a much desired surface finish.

The men connected with the early development of sand control really belong in our "Hall of Fame." With the old hand control method of trial and error many castings were made but, as in all other lines of manufacturing, scientific control and continued research makes mass production possible today. The "practical foundryman" and the daily reports on the condition of his sand are a team much like the melter and his regular reports of the metal composition.

The advantages of sand control have been demonstrated on castings of simple design, with good gating and feeding methods, and proved many times by the use of the right and wrong sands. Sands, with moisture, permeability and bond properly controlled, can give castings free from hot tears, cracks and sand defects, while a sand with a high moisture content, with low permeability and high bond may show castings with defects such as scabs, hot tears and rough finish.

Different Sands Used

In the production of large quantities of various sized castings used for light and heavy duty trucks, tractors, agricultural implements and ordnance vehicles, several different heap and facing sand mixtures are used.

Many agricultural castings when annealed, cleaned and straightened are used in the "as-cast" condition, one casting working into another and held to close tolerances for foundry fits, that is, fits which must be satisfactory without machining. This is very general in chain links, roller bearing ends, and other small castings. The manufacturing tolerances are plus or minus 0.006 in. on chain links and plus or minus 0.007 in. on roller bearing ends.

Sand Conditioning Equipment

To keep the sand heaps in condition four gasoline motor driven sand cutters are used. These sand cutters handle the majority of the sand used in the foundry. Heaps are cut twice daily after the heats are poured, and by proper cutting good mixing and aerating are obtained. The second cutting is made immediately after the first heat.

Six portable sand-conditioning units are used on the large molding machine floors. These machines give a well mixed and well aerated sand in addition to removing tramp iron, chills and core butts. They require more manpower to operate than does a sand cutter.

Sands for Light Castings

A sandslinger is used as a sand conditioner and as a molding unit. This piece of equipment is very efficient both as a sand conditioner and a mold producing unit. Three intensive mullers furnish sufficient facing sand for the daily requirements.

On floors where the smaller castings such as chain links, roller bearing ends, knife clips, etc., are made, frequent additions of ground rock sand (4-6 per cent A.F.A. clay content, 240 fineness and 16-20 permeability at 5 per cent moisture) are made. Sands with a good flowability are required for this type of work

Examples of medium sized malleable castings showing gating method.

in order to meet the exacting inspection requirements for finish and dimensions (Table 1).

These small castings require special finishes, are closely inspected, and sands of a lower bond which have less tendency to burn on are used. No sea coals or dust-on facing materials are used on these light castings to improve the finishes. It has been the experience in this plant that sea coal and dust-on facings tend to cause hot cracks on castings of intricate design.

Sands for Medium Size Castings

The physical properties of individual heaps for squeezer machines on medium sized castings are kept in condition by adding a natural-bonded sand. This is a sand with an 11-13 per cent A.F.A. clay content, with a 200 fineness and a 25 permeability at 6 per cent moisture (Table 2). This is added on the heap before the sand is cut to get the most effective results.

Sand heaps for producing medium sized castings may retain a considerable amount of core sand from the shakeout, and the permeability generally is much higher than that of the new sand. There will also be a considerable amount of facing sands used in these heaps, which would tend to keep up the bond to a sufficient extent.

Again, there may be sufficient permeability so that a mulled bond could be added to the heap before cutting, as well as some new lake sand. Many heaps used for medium sized castings may require from 10 to 20 cu. ft. of facing sand to obtain the required finish. This may be as much as 10 per cent of the sand on the floor.

Sands for Heavy Castings

Sands used on heaps making the heavier castings on large jolt machines generally have a higher permeability due to a larger volume of retained core sand (Table 3). The

Written discussions of this paper are solicited for publication in future issues of "American Foundryman" and/or bound volume of "Transactions." Discussions should be sent to Secretary, American Foundrymen's Association, 222 West Adams St., Chicago 6.

Table 1

DAILY SAND TESTS FOR LIGHT WORK

	Chain Links			*Roller Bearing Ends*		
	Heap Sand			*Heap Sand*		
Sample No.	*Moisture, per cent*	*Permeability*	*Green Strength, psi.*	*Moisture, per cent*	*Permeability*	*Green Strength, psi.*
1	6.2	37	4.6	4.8	20	5.4
2	6.4	45	3.9	6.6	24	4.5
3	6.0	42	4.2	6.2	31	3.8
4	6.0	38	4.3	7.4	35	3.8
5	5.8	47	3.9	6.6	33	3.5
6	5.6	42	3.5	6.4	27	3.6

Table 2

DAILY SAND TESTS FOR MEDIUM WORK

	Heap Sand			*Facing Sand*		
Sample No.	*Moisture, per cent*	*Permeability*	*Green Strength, psi.*	*Moisture, per cent*	*Permeability*	*Green Strength, psi.*
1	5.6	90	4.9	3.6	165	9.8
2	6.0	100	5.4	3.8	160	10.3
3	5.2	100	4.7	3.6	165	9.2
4	5.2	90	6.3	4.2	150	9.4
5	4.8	95	5.8	3.6	180	11.0
6	5.0	105	5.5	3.6	175	8.5
7	5.2	90	4.6	3.8	180	8.3
* 8	4.4	135	6.0	3.5	170	8.1
* 9	4.8	135	5.3	3.6	130	10.7
* 10	4.2	130	6.9	3.8	135	11.2
* 11	3.7	130	8.1	3.5	145	10.3
12	3.9	140	6.7	3.9	140	9.9

*These are samples from sand heaps and facings that are used to make castings of a special design which are very prone to crack and which require special finishes.

Table 3

DAILY SAND TESTS FOR HEAVY WORK

	Heap Sand			*Facing Sand*		
Sample No.	*Moisture, per cent*	*Permeability*	*Green Strength, psi.*	*Moisture, per cent*	*Permeability*	*Green Strength, psi.*
1	4.2	170	8.2	4.0	170	11.8
2	3.9	165	5.7	4.2	160	10.9
3	4.0	180	6.4	3.8	175	11.3
4	4.2	160	6.0	3.8	170	11.7
5	4.2	160	4.5	3.8	185	9.5
6	4.1	175	4.7	3.6	150	9.9
7	4.0	155	5.8	4.0	170	10.5
8	4.0	155	6.6	3.9	175	10.2
9	3.6	175	7.2	3.8	165	11.6
10	4.6	170	5.4	4.1	170	10.7

Table 4

DAILY SAND TESTS FOR TRUCK WHEELS

	Heap Sand			*Facing Sand*		
Sample No.	*Moisture, per cent*	*Permeability*	*Green Strength, psi.*	*Moisture, per cent*	*Permeability*	*Green Strength, psi.*
1	4.0	145	4.8	3.2	170	10.8
2	3.6	150	5.1	3.3	165	10.8
3	4.1	140	4.2	3.2	170	11.1
4	3.6	140	5.9	3.4	180	10.4
5	3.8	145	5.5	3.3	185	9.7
6	3.6	150	5.7	3.4	180	10.5
7	3.8	150	5.3	3.3	185	10.6
8	3.4	145	5.6	3.3	180	10.2
9	3.6	145	5.9	3.4	180	10.5
10	3.4	150	5.2	3.4	185	10.1
11	3.8	155	4.3	3.3	185	9.7
12	3.4	155	5.6	3.4	180	9.6

Table 5

FACING SAND MIXTURES

Light Castings	*Medium Castings (Regular)*	*Medium Castings (Open)*
24 parts Heap Sand	30 parts Heap Sand	20 parts Heap Sand
12 parts New Molding Sand	10 parts New Lake Sand	20 parts New Lake Sand
4 parts New Lake Sand	3 parts Clay Bond	2½ parts Clay Bond
	(2 parts of sea coal are added only when required)	4 parts New Molding Sand

Heavy Castings (Regular)	*Truck Wheels*
20 parts Heap Sand	20 parts Heap Sand
20 parts New Lake Sand	20 parts New Lake Sand
3 parts Clay Bond	3½ parts Clay Bond
2½ parts Sea Coal	2½ parts Sea Coal

physical properties of these heaps are kept up to molding sand requirements by frequent additions of natural bonded sand or a mixture of colloidal clay mulled with new lake sand.

Closely controlled facing sands used on the heavy castings have small quantities of a coarse grade of sea coal. The facing sands also help to keep the sand open and the green strength up to standard.

The sand from the slinger floor used in molding truck wheels is checked each hour. Samples are taken after passing through the head, as it is found that permeability is somewhat reduced through the head. On this floor only synthetic sands are used. Rebonding is done with a mixture of 10 parts of colloidal clay and 40 parts of new lake sand mixed in a muller. Enough is added each day to maintain predetermined standards by additions on molds before shakeout (Table 4).

Sea Coal Added

Facing sand with sea coal additions for truck wheel castings is used on the cope side of patterns only as a means of lifting the deep pockets. Rigid standards are used on truck wheel facing sand as it must have just sufficient green strength to lift the mentioned pockets.

Moisture is kept low so as not to bake too hard for easy contraction of castings. This particular job is susceptible to hot cracks unless all involved materials are at the highest possible workable standards.

The tests shown in Tables 3 and 4 are made on samples from different floors, some of which require a higher green strength than others depending upon the size and shape of the flask and the nature of the casting in production.

Facing sand mixtures are varied according to the size and requirements of the castings. On some fairly heavy castings it has been found desirable to have a more open facing. Typical examples of the mixtures used for the various facings are shown in Table 5.

Each foreman and his assistants have a particular class of work for which they must choose the sands and the facing which are best suited to the requirements of the casting. The right sand for each specific casting is not enough. It is the day-to-day uniformity, which is maintained by frequent testing and regular adjustments, that counts in the long run for quality production.

It is the purpose of this paper primarily to record the details of the sand control practice used in this foundry. It is the faithful adherence to control that results in a better casting and more satisfactory production.

A.F.A. MEMBERS HELP

Uncover German Technical Ideas

FROM American industries, colleges and government agencies were drawn more than 200 American technical experts to investigate Germany's technical industrial war secrets. This program is being carried out under the direction of the Joint Chiefs of Staff, and in conjunction with the Foreign Economic Administration and other governmental agencies. Most of the investigators were sent out by FEA. It can be stated that much important data has been obtained and some investigators have completed their work and returned. However, the greatest number are overseas and others are going over.

J. T. MacKenzie

F. L. Wolf

Under the direction of the military, and in association with other governmental agencies, FEA began adding experts to its staff for dispatch into Germany as soon as the military situation permitted.

New developments discovered which are related to the foundry field include: new applications of radiation devices; new and improved x-ray tubes for industrial purposes and information on high temperature alloys unknown in this country.

The civilian technical personnel who have returned or are still overseas include the following A.F.A. members: Fred L. Wolf, Philadelphia; Earnshaw Cook, American Brake Shoe Co., Mahwah, N. J.; James T. MacKenzie, American Cast Iron Pipe Co., Birmingham; Carl M. Leob, Jr., Climax Molybdenum Co., New York; J. D. Hanawalt, Dow Chemical Co., Midland, Mich.; Sam Tour, Sam Tour & Co., New York; and C. W. Briggs, Steel Founders' Society, Cleveland.

C. W. Briggs

Sam Tour

Relative Effect of

LIME AND DOLOMITE FLUXES

On Cupola Irons and Cupola Operation

● *This report describes experiments performed to determine the effect of substituting dolomite for limestone as a cupola flux. Data are presented to show the effect of the slags on the sulphur, carbon, silicon, phosphorus and manganese contents of the irons, and on their physical properties.*

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DOLOMITE has been recommended in reports of Reese[1] and Dierker[2] as a cupola flux, lower viscosity for the magnesia-bearing slags being claimed. McCaffery and co-workers[3] published data showing a marked decrease in viscosity of three component, synthetic slags (Al_2O_3, SiO_2, CaO) produced by the introduction of magnesia in amounts of 5 to 20 per cent.

The viscosity of the magnesia slags was found to be less sensitive to changes in composition with respect to total base content than the corresponding plain lime slags. Field and Royster[4] showed a reduction in blast furnace slag viscosity with an increase in magnesia content from 1.5 to 7.5 per cent, the sum of the CaO and MgO being kept constant at 45.67 per cent.

Dierker[5] has presented some data indicating a 50 per cent decrease in sulphur pick-up by cupola cast iron when dolomite was substituted for limestone, and[2] has stated that the composition of the slag has an effect on the physical properties of the metal. McCaffery and co-workers[6] have claimed lower sulphur pig and smoother operation for blast furnaces adding dolomite flux in amounts calculated to change the mineral make-up of the slag in the furnace.

John W. Bolton in his book, "Gray Cast Iron," makes the following statement: "General opinion is that dolomite limestones are somewhat more powerful in their fluxing action, but in slags less absorbent toward sulphur than straight calcium limestones."

A cupola lined to an inside diameter of 24 in. and equipped with a constant weight blower was employed. The general procedure was to run heats in pairs, the members of each pair being the same with respect to charge, bed height, blast, etc., but differing in the flux employed, one heat being fluxed with lime and the other with dolomite.

Melting data are presented in Table 1. Each heat consisted of 12 charges. The first charge was all scrap. The remaining 11 charges were of steel, returns, and pig in the proportions given in the table.

Nine taps were made during each heat. The first tap, the all-scrap charge, was pigged. The remaining eight taps were designated alphabetically. For example, 6B indicates tap B (the third tap) from the sixth heat.

Three extra charges were made in each heat to prevent irregularities in blast and pressure during the last taps, the metal being recovered from the drop. In addition, extra coke charges were made after the last metal charge had descended the cupola stack. Coke for the bed was

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Table 1

SUMMARY OF MELTING DATA

Heat		Steel, lb.	Pig, lb.	Returns, lb.	Coke, lb.	Flux, lb.	Bed, in.	Blast, oz.	Air, lb./min.	Average Temp., °F.
1.	Lime	47	135	118	37	11	40	9.2	62.5	2708
2.	Dolomite	47	135	118	37	11	40	8.8	62.5	2722
3.	Lime	32	165	103	43	11	42	10.3	65.0	2746
4.	Dolomite	32	165	103	43	11	42	9.7	65.0	2729
5.	Lime	40	152	108	43	11	43	9.4	65.0	2704
6.	Dolomite	40	152	108	43	11	43	9.0	65.0	2688
7.	Lime	40	150	110	43	11	43	11.1	62.5	2675
8.	Dolomite	40	150	110	43	11	43	10.1	62.5	2700
9.	Lime	40	135	125	43	11	40	8.6	57.0	2745
10.	Dolomite	40	135	125	43	11	40	8.4	57.0	2717
11.	Lime	50	142	110	60	11	42	8.2	60.0	2800
12.	Dolomite	50	142	110	60	11	42	8.8	60.0	2759
13.	Lime	44	112	146	43	11	42	7.2	62.5	2766
14.	Dolomite	44	112	146	43	11	42	7.0	62.5	2748
15.	Lime	45	110	155	43	11	42	5.7	63.0	2759
16.	Dolomite	45	110	155	43	11	42	6.5	63.0	2774
17.	Lime	35	190	73	43	12	43	8.5	60.0	2680
18.	Dolomite	35	190	73	43	12	43	8.5	60.0	2680
19.	Lime	25	145	130	43	12	40	8.4	60.0	2712
20.	Dolomite	25	145	130	43	12	40	8.6	60.0	2703

Table 2

CHEMICAL ANALYSIS OF FLUXES

	Component, per cent				
	SiO_2	CaO	MgO	R_2O_3	S
Lime	1.00	53.3	1.23	0.60	0.025
Dolomite	0.32	29.2	20.4	0.22	0.027

added and allowed to burn to redness. The bed height was adjusted by a small coke addition. A double charge of flux was added on the top of the bed.

The components of each metal charge were carefully weighed and added in the following order: steel, pig, returns. The steel was structural, cut into small pieces not exceeding ⅜ in. in thickness. Small pigs from two lots of iron were used. The pigs were broken into pieces weighing approximately 20 lb. Returns from each previous pair of heats were broken up and distributed as uniformly as possible in order to prevent variations in the chemical analysis of the charges of any one pair of heats.

Two-inch coke was used in all heats in the proportions indicated in the table. Coke from more than one lot was employed, but the coke in one pair of heats was of the same lot in all cases.

The blast was controlled with a constant weight blower. The air in lb. per min. is given in the table. The blast pressures are averages of wind box pressure readings taken during the heat.

Reference to Table 1 shows considerable variation in blast pressure between pairs of heats. This is attributed to variation in the nature of the coke and metal charges, atmosphere changes, etc. Conditions were kept constant for the members of each pair in order to eliminate these various factors as variables.

Temperature readings were taken at the spout with an optical pyrometer. The values in Table 1 are average values for the taps of each heat. Practically all temperature readings were in the range of 2,800 to 2,650° F.

Chemical analysis of the lime and dolomite employed are given in Table 2. The flux was added on top of each coke charge.

Two Series Run

Two series of heats were run. The first series, consisting of eight pairs or 16 heats, was made with the slag hole open, slagging the furnace just prior to each tap. This series consists of all heats up to and including no. 16.

The second series, of four heats, was run with the slag hole closed, allowing the slag to accumulate during the entire heat. The purpose of these heats was to determine the relative desulphurizing power of lime and dolomite slags when a heavy layer of slag was present in the cupola.

A complete chemical analysis of all the taps of a number of heats from series 1 was made. Three transverse test bars and a chill test wedge were poured from each tap of these heats. All taps of all the heats were completely analyzed for sulphur by the evolution method.

The cupola lining was restored to 24 in. after each heat, using a plastic mixture of 2 parts sand and one part fire clay.

Table 3 gives the results of sulphur determinations for the first series; Table 4, the results for the

Table 4

INFLUENCE OF LIME AND DOLOMITE FLUXES ON SULPHUR CONTENT OF CUPOLA IRONS. SERIES 2 CUPOLA NOT SLAGGED.

	Heats 17 and 18		Heats 19 and 20	
Tap	Lime	Dolomite	Lime	Dolomite
A	.098	.083	.111	.113
B	.069	.066	.085	.094
C	.069	.066	.084	.085
D	.065	.075	.081	.080
E	.068	.069	.079	.082
F	.072	.069	.076	.079
G	.067	.068	.077	.084
H	.066	.069	.081	.074
Average	.072	.071	.084	.086

Table 5

ANALYSIS OF SLAGS.

	Per Cent			
Heat	SiO_2	FeO	MgO	CaO
1	42.20	2.38	1.92	31.11
2	41.90	3.00	14.10	20.21
9	44.24	2.90	1.38	31.85
10	42.56	2.92	11.70	18.82
17	42.86	3.94	1.67	35.00
18	42.02	3.22	14.60	22.80

Table 6

CHEMICAL ANALYSIS OF HEATS 1 AND 2 BY TAP.

Tap	C	Si	Mn	P	S
	Per Cent				
Heat 1—Limestone					
A	3.58	2.02	0.54	0.28	0.100
B	3.55	2.05	0.59	0.27	0.090
C	3.48	2.05	0.60	0.33	0.089
D	3.37	2.00	0.63	0.34	0.084
E	3.38	1.98	0.61	0.35	0.086
F	3.38	1.96	0.60	0.32	0.086
G	3.33	1.90	0.71	0.31	0.082
H	3.38	1.90	0.58	0.30	0.078
Average	3.43	1.98	0.61	0.31	0.087
Heat 2—Dolomite					
A	3.60	1.96	0.53	0.32	0.112
B	3.50	2.05	0.59	0.29	0.092
C	3.43	2.06	0.62	0.33	0.089
D	3.31	2.02	0.61	0.29	0.090
E	3.31	1.97	0.61	0.31	0.087
F	3.35	1.96	0.62	0.33	0.086
G	3.31	1.86	0.64	0.31	0.087
H	3.26	1.87	0.61	0.30	0.087
Average	3.38	1.97	0.60	0.31	0.091

Table 3

INFLUENCE OF LIME AND DOLOMITE FLUXES ON SULPHUR CONTENT OF CUPOLA IRONS. CUPOLA SLAGGED INTERMITTENTLY.

Tap	Heats 1 2		Heats 3 4		Heats 5 6		Heats 7 8		Heats 9 10		Heats 11 12		Heats 13 14		Heats 15 16	
	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D
A	.100	.112	.093	.099	.105	.113	.101	.107	.107	.124	.124	.117	.119	.113	.115	.121
B	.090	.092	.085	.097	.093	.102	.088	.088	.101	.118	.106	.112	.115	.119	.112	.108
C	.089	.089	.092	.090	.091	.094	.089	.085	.091	.108	.098	.102	.124	.116	.109	.114
D	.084	.090	.087	.089	.085	.093	.087	.084	.093	.103	.089	.102	.116	.121	.108	.111
E	.086	.087	.082	.090	.079	.085	.081	.080	.093	.100	.090	.101	.113	.117	.109	.113
F	.086	.086	.078	.089	.083	.078	.079	.084	.094	.098	.096	.105	.110	.112	.112	.108
G	.082	.087	.079	.085	.082	.078	.080	.084	.089	.102	.091	.100	.114	.118	.110	.108
H	.078	.087	.079	.081	.073	.079	.076	.087	.093	.098	.100	.108	.114	.117	.107	.107
Average	.087	.091	.084	.090	.086	.090	.098	.100	.095	.106	.099	.106	.116	.117	.110	.111

Table 7

CHEMICAL ANALYSIS OF HEATS 3 AND 4 BY TAP.

Tap	Heat 3—Limestone C	Si	Mn	P	S	Heat 4—Dolomite C	Si	Mn	P	S
A	3.52	2.07	0.59	0.29	0.093	3.64	2.13	0.59	0.29	0.099
B	3.60	2.14	0.62	0.31	0.085	3.60	2.14	0.61	0.30	0.097
C	3.58	2.04	0.61	0.31	0.092	3.54	2.10	0.61	0.29	0.090
D	3.54	2.04	0.62	0.31	0.087	3.53	2.12	0.65	0.29	0.089
E	3.52	2.06	0.64	0.31	0.082	3.34	2.11	0.62	0.31	0.090
F	3.53	2.09	0.64	0.31	0.078	3.51	2.16	0.63	0.31	0.089
G	3.50	2.07	0.65	0.31	0.079	3.48	2.10	0.63	0.32	0.085
H	3.49	2.05	0.64	0.31	0.079	3.50	2.18	0.63	0.32	0.081
Average	3.53	2.07	0.63	0.31	0.084	3.54	2.13	0.62	0.30	0.090

Table 8

CHEMICAL ANALYSIS OF HEATS 5 AND 6 BY TAP.

Tap	Heat 5—Limestone C	Si	Mn	P	S	Heat 6—Dolomite C	Si	Mn	P	S
A	3.60	2.09	0.56	0.34	0.105	3.49	2.13	0.59	0.34	0.113
B	3.52	2.10	0.58	0.32	0.093	3.50	2.16	0.60	0.33	0.102
C	3.56	2.08	0.58	0.33	0.091	3.51	2.14	0.60	0.32	0.094
D	3.50	2.09	0.61	0.33	0.085	3.46	2.07	0.59	0.33	0.093
E	3.53	2.12	0.61	0.32	0.079	3.51	2.12	0.61	0.34	0.085
F	3.51	2.08	0.61	0.32	0.083	3.53	2.13	0.59	0.31	0.078
G	3.52	2.09	0.58	0.32	0.082	3.46	2.15	0.63	0.35	0.078
H	3.52	2.03	0.60	0.33	0.073	3.42	2.15	0.63	0.34	0.079
Average	3.53	2.09	0.59	0.33	0.086	3.48	2.13	0.61	0.33	0.090

Table 9

CHEMICAL ANALYSIS OF HEATS 7 AND 8 BY TAP.

Tap	Heat 7—Limestone C	Si	Mn	P	S	Heat 8—Dolomite C	Si	Mn	P	S
A	3.46	2.09	0.57	0.34	0.101	3.42	2.11	0.57	0.34	0.107
B	3.47	2.05	0.57	0.33	0.088	3.42	2.14	0.61	0.33	0.088
C	3.41	2.15	0.59	0.33	0.089	3.44	2.15	0.60	0.35	0.085
D	3.39	2.11	0.60	0.35	0.087	3.40	2.16	0.60	0.35	0.084
E	3.40	2.12	0.59	0.33	0.081	3.36	2.06	0.59	0.34	0.080
F	3.29	2.23	0.62	0.34	0.079	3.33	2.06	0.59	0.34	0.084
G	3.30	2.21	0.61	0.35	0.080	3.34	2.08	0.59	0.32	0.084
H	3.28	2.11	0.60	0.35	0.076	3.29	2.14	0.60	0.33	0.087
Average	3.38	2.13	0.59	0.34	0.098	3.38	2.11	0.59	0.34	0.100

Table 10

CHEMICAL ANALYSIS OF HEATS 9 AND 10 BY TAP.

Tap	Heat 9—Limestone C	Si	Mn	P	S	Heat 10—Dolomite C	Si	Mn	P	S
A	3.39	2.02	0.54	0.37	0.107	3.40	2.06	0.53	0.37	0.124
B	3.48	2.06	0.57	0.36	0.101	3.39	2.10	0.56	0.35	0.118
C	3.36	2.10	0.59	0.36	0.091	3.33	2.11	0.57	0.36	0.108
D	3.33	2.00	0.58	0.38	0.093	3.37	2.09	0.55	0.35	0.103
E	3.36	2.01	0.59	0.38	0.093	3.32	2.10	0.57	0.38	0.100
F	3.32	1.90	0.57	0.37	0.094	3.35	2.07	0.57	0.38	0.098
G	3.41	2.06	0.60	0.36	0.089	3.37	2.03	0.56	0.36	0.102
H	3.39	2.01	0.58	0.38	0.093	3.38	2.06	0.55	0.40	0.098
Average	3.38	2.02	0.58	0.37	0.095	3.37	2.08	0.57	0.37	0.106

Table 11

CHEMICAL ANALYSIS OF HEATS 11 AND 12 BY TAP.

Tap	Heat 11—Limestone C	Si	Mn	P	S	Heat 12—Dolomite C	Si	Mn	P	S
A	3.53	2.02	0.52	0.31	0.124	3.53	2.19	0.57	0.32	0.117
B	3.46	2.09	0.60	0.32	0.106	3.46	2.20	0.61	0.32	0.112
C	3.47	2.14	0.62	0.32	0.098	3.43	2.19	0.62	0.32	0.102
D	3.45	2.14	0.63	0.32	0.089	3.40	2.18	0.63	0.32	0.102
E	3.40	1.96	0.62	0.31	0.090	3.42	2.19	0.63	0.31	0.101
F	3.39	2.07	0.63	0.31	0.096	3.39	2.13	0.61	0.30	0.105
G	3.41	2.13	0.62	0.34	0.091	3.43	2.14	0.62	0.32	0.100
H	3.34	2.07	0.61	0.31	0.100	3.40	2.01	0.58	0.31	0.108
Average	3.43	2.08	0.61	0.32	0.099	3.43	2.15	0.61	0.32	0.106

Written discussions of this paper are solicited for publication in future issues of "American Foundryman" and/or bound volume of "Transactions." Discussions should be sent to Secretary, A.F.A., 222 West Adams St., Chicago 6.

second series. The figures are the average of two determinations. These data indicate that the limestone is not inferior to dolomite in desulphurizing ability. In those cases where an appreciable difference appears in the average sulphur content for the heat, the limestone heats have the lowest sulphur irons. Of the 64 pairs of irons of series one, 48 (75 per cent) show higher sulphurs in the dolomite heats.

A number of slags were analyzed for CaO, MgO, FeO, and SiO_2 contents. Results are presented in Table 5. The magnesia contents of the dolomite slags are in the range which should produce a slag of low viscosity relative to the plain lime slag. The data indicate slags within the composition limits recommended for good cupola practice.

Slag Analysis

The figure for iron oxide is for total iron reported as ferrous oxide. Slag samples were collected just before tap "E" in the case of those heats which were slagged intermittently. The slags as collected in a half-inch layer in an iron pot were dark green with brownish colored streaks.

No difference in the appearance of the lime slags as compared with the dolomite slags could be detected. All slags showed some tendency to wool at the slag hole.

No variation in the viscosity of the lime and dolomite slags was apparent as judged by the flow from the slag hole. Examination of cupola lining disclosed no correlation between lining condition and the type of flux used.

Tables 6 to 11 give the complete analysis of all heats from 1 to 12. The average values for all the taps of each heat are presented in Table 12. No effect of the fluxes on carbon, manganese, phosphorus and silicon contents can be established from these data, with the possible exception of a tendency for the sili-

Table 12

AVERAGE CHEMICAL ANALYSIS BY HEAT.

	Limestone						Dolomite				
Heat	C	Si	Mn	P	S	Heat	C	Si	Mn	P	S
1	3.43	1.98	0.61	0.31	0.087	2	3.38	1.97	0.60	0.31	0.091
3	3.53	2.07	0.63	0.31	0.084	4	3.54	2.13	0.62	0.30	0.090
5	3.53	2.09	0.59	0.33	0.086	6	3.48	2.13	0.61	0.33	0.090
7	3.38	2.13	0.59	0.34	0.098	8	3.38	2.11	0.59	0.34	0.100
9	3.38	2.02	0.58	0.37	0.095	10	3.37	2.08	0.57	0.37	0.106
11	3.43	2.08	0.61	0.32	0.099	12	3.43	2.15	0.61	0.32	0.106

Table 13

SUMMARY OF RESULTS ON PHYSICAL TESTS BY TAP.

	Limestone							Dolomite						
Iron	C	Si	Tensile Strength, psi.	Transverse Strength, psi.	Deflection, in.	BHN	Chill, in.	Iron	C	Si	Tensile Strength, psi.	Transverse Strength, psi.	Deflection, in.	BHN	Chill, in.
1D	3.37	2.00	35,640	2,287	0.270	210	0.55	2D	3.31	2.02	35,040	2,403	0.280	207	0.50
1F	3.38	1.96	35,170	2,363	0.290	217	0.47	2F	3.35	1.96	36,470	2,454	0.302	211	0.50
3B	3.60	2.14	26,980	1,946	0.272	192	Defec.	4B	3.60	2.14	25,050	1,806	0.273	181	Defec.
5D	3.50	2.09	32,410	2,246	0.294	197	0.28	6D	3.46	2.07	31,400	2,222	0.300	199	0.28
5E	3.53	2.12	30,290	2,164	0.299	187	0.30	6E	3.51	2.12	32,150	2,231	0.279	195	0.33
7A	3.64	2.09	29,490	2,076	0.303	186	0.28	8A	3.42	2.11	32,150	2,199	0.271	192	0.32
7C	3.41	2.15	33,000	2,265	0.295	191	0.32	8C	3.44	2.15	32,830	2,228	0.269	194	0.28
7H	3.28	2.11	34,270	2,367	0.286	197	0.28	8H	3.29	2.14	33,400	2,331	0.282	196	0.32
9A	3.39	2.02	27,830	2,215	0.333	185	0.22	10A	3.40	2.06	32,840	2,377	0.267	195	0.22
9C	3.36	2.10	33,350	2,395	0.320	195	0.30	10C	3.33	2.11	36,290	2,552	0.318	202	0.30
9G	3.41	2.06	34,200	2,444	0.309	203	0.28	10G	3.37	2.03	34,700	2,532	0.303	210	0.25

con loss to run slightly higher in the heats where limestone was used.

Test bars were selected from corresponding taps of each pair of heats where the analysis of the two taps were in close agreement. Results, with the silicon and carbon contents of the irons, are in Table 13. Transverse strengths are the average of three 1.2-in. standard transverse bar results.

The bars were poured in oil sand cores coated with a non-carbonaceous wash. Brinell readings were taken on sections from the transverse bars. Tensile specimens were machined from the transverse pieces. The tensile results are based on one bar. The chill test employed was a small wedge poured in a core sand mold.

Sections for examination under the microscope were prepared from the bars of Table 13. No relation between flux and the microstructure of the irons was found.

Discussion and Conclusions

The following conclusions apply when dolomite is substituted for limestone on a lb. for lb. basis in amounts which are recommended for good cupola practice, and which produce slags within the composition limits recommended in the literature for satisfactory operation of the cupola:

1. The substitution of dolomite for limestone in amounts of about 4 per cent of the metal charge results in no advantage as far as reduction of sulphur content of the iron is concerned. A total of 20 heats were run in pairs, one member of the pair under dolomite and the other under limestone. In those cases where an appreciable difference was found in the average sulphur content for the heat, the limestone heats had the lower sulphur irons.

2. The substitution of dolomite for limestone does not change the carbon, phosphorus or manganese contents of the iron. The possibility of a slightly greater silicon loss for the limestone heats is indicated.

3. The physical properties and the microstructures of the irons are not influenced by changing from limestone to dolomite.

4. The use of dolomite in place of limestone does not improve the operation of the cupola as far as slagging or lining attack is concerned.

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Foundries Demand Opening Of British Foundry School

A CURRENT issue of *Mechanical Handling*, England, reports that at a meeting of the Governing Body held in London and attended by representatives of trade associations, research associations, scientific and professional institutions, and numerous firms, it was unanimously agreed to reopen the British Foundry School as soon as possible.

Birmingham is being considered as the best location for the school.

Caterpillar Cooperates

(Continued from Page 64)

ficers. A member of the training department of the plant conducts the classroom instruction, assists in selection of the students, and aids the coordinator in making the plan effective.

Results of this program have been gratifying. While the majority of the participants either have gone or soon will go into military service, those not physically qualified have transferred to the regular staff of the department in which they did their cooperative work. When the military no longer calls these students to service, the cooperative training program will be an excellent source for future laboratory personnel.

Trainees Satisfactory

Work by the trainees has been entirely satisfactory from the company standpoint. The value to the trainees has been even greater. They have gained valuable experience in dealing with people and physical things. They have discovered the business world at an early age and, most important of all, have learned whether the profession they chose in high school should be their life's work.

If any trainees find that this is not the career for them, they may have saved themselves years of training in a business for which they are unfitted. On the other hand, if their work here has proved their decision right, they will be better chemists or metallurgists as the result of this early training.

Reflectoscope Inspects Metal Via Sound Waves

AN instrument for inspecting the interior of metal parts by means of sound waves has been developed by F. A. Firestone, department of engineering, University of Michigan, Ann Arbor, Mich.

The supersonic reflectoscope sends into the metal part to be inspected, a short wave train of high frequency sound waves. The presence of interior flaws can be detected by observing the sound waves which they reflect back to the sending point. About five sound waves are sent out in one-millionth of a second; in aluminum or steel these waves will travel one inch in four-millionths of a second. When the waves encounter a flaw they are partially reflected back to the sending point before the receipt of the reflection from the other side of the piece, thus indicating the presence of an internal flaw.

The reflections are indicated on a cathode ray oscilloscope built into the instrument. The sensitivity is such that a drilled hole .010-in. in diameter and 0.25-in. long can be detected when several inches from the sending point. Several feet of metal can be penetrated using the reflectoscope.

Other Uses

The method is useful not only for the detection of flaws, but for the detection of bond in soldered or plated parts. Also useful for the measurement of the thickness of parts where the opposite wall is inaccessible.

(Photo courtesy John Bing, A. P. Green Fire Brick Co.)

The Board of Awards presented medals to Robert E. Kennedy and Clarence E. Sims at the Annual Business Meeting banquet held July 18. (Above) Past President H. S. Simpson, National Engineering Co., Chicago, and Board of Awards member, presents the Joseph S. Seaman Gold Medal to Robert E. Kennedy, Secretary, American Foundrymen's Association. (Below) Past President L. C. Wilson, Reading Steel Casting Div., American Chain & Cable Co., Reading, Pa., and Chairman, Board of Awards, hands the John A. Penton Gold Medal to Clarence E. Sims, Supervising Metallurgist, Battelle Memorial Institute, Columbus, Ohio.

NEW ASSOCIATION MEMBERS

(August 16 to September 15, 1945)

• With the beginning of the new season of chapter meetings, our old members will have the pleasure of welcoming many new members to Association activities. Friendship in a group working together in a common industry is one of the most valuable A.F.A. membership benefits. The Association is pleased to welcome the 122 new members reported here and which represent twenty-four A.F.A. chapters. Old chapter members now have the opportunity of making these members, and members listed in past issues of American Foundryman, welcome as they meet with you month to month.

Conversion from Company to Sustaining

Sully Brass Foundry, Ltd., Toronto, Ont., Canada (Jos. Sully, Pres. and Gen. Mgr.) (Ontario Chapter).

Conversion from Personal to Company

McIlwraith Industries Pty Ltd., Waterloo, N. S. W., Australia (R. M. Coleman, Gen. Mgr.).
Chambersburg Engineering Co., Chambersburg, Pa. (Douglas G. Galloway, Fdry. Supt.) (Chesapeake Chapter).

BIRMINGHAM CHAPTER

Wm. W. Austin, Jr., Met., Southern Research Institute, Birmingham, Ala.
Edward W. Crudup, Sales, The Cleveland Flux Co., Dallas, Texas.
C. S. Hamby, Supt., Southern Wheel Div., American Brake Shoe Co., Atlanta, Ga.
B. L. Hayes, Asst. Chief Electrician, American Cast Iron Pipe Co., Birmingham.
Harry B. Owen, Supt. of Operations, Alabama By-Products Corp., Tarrant, Ala.
Charles F. Walters, Jr., in Charge of Experimental and Test Foundry, Alabama By-Products Corp., Tarrant, Ala.
L. W. Williams, Sales Engr., U. S. Pipe & Foundry Co., Birmingham, Ala.

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George M. Becker, Production Supv., Union Metal Mfg. Co., Canton, Ohio.
Clarence S. Duerr, Pattern Foreman, Union Metal Mfg. Co., Canton, Ohio.

CENTRAL INDIANA CHAPTER

Joseph M. Fordney, Chief Melter, The Perfect Circle Co., New Castle, Ind.
Wilbur S. Werking, Foreman, Machine Shop, The Perfect Circle Co., New Castle, Ind.

CHESAPEAKE CHAPTER

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H. D. Hammond, Head of Standards, Brake Shoe and Castings Div., American Brake Shoe Co., Baltimore, Md.
Chao Chu Kung, Major, The Chinese Air Force, Washington, D. C.
J. B. Morrow, Jr., Supt., Southern Wheel Div., American Brake Shoe Co., Portsmouth, Va.
G. W. Tynes, Asst. Supt., National Bearing Div., American Brake Shoe Co., Portsmouth, Va.

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Dean B. Burks, Met., Dodge Chicago Plant, Chicago.
Harry E. Clo, Engr., Air Filter & Equipment Co., Chicago.
John C. Day, Asst. Chief Inspector, American Steel Foundries, East Chicago, Ind.
Bolton A. Dixner, Head Melter, American Steel Foundries, East Chicago, Ind.
Geo. J. Foss, Chief Met., Universal Castings Corp., Chicago.
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Perry A. McArthur, Sales, S. Obermayer Co., Chicago.
H. A. Nichol, Service Engr., Master Tool Co., Inc., Chicago.
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Wm. W. Sopher, Research Met., Universal Castings Corp., Chicago.
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Chen Wang-Lung, International Harvester Co., Tractor Works, Chicago.
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John Knox Taylor, Mgr., Taylor Refractories & Insulation Co., Cincinnati.

*Company members.

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P. Scribante, Foundry Foreman, American Manganese Steel Div., American Brake Shoe Co., Los Angeles.
Keith Spencer, Partner, California Iron & Metals Co., Los Angeles.
Richard Summers, T/3, Corps of Engineers, U.S.A.

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TOLEDO CHAPTER

J. D. Freeman, Supt., Southern Wheel Div., American Brake Shoe Co., Toledo.

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Walter E. Sweet, Mgr., Twin City Steel Treating Co., Minneapolis.

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Joseph J. Olejniczak, Time Study Man, American Seating Co., Grand Rapids, Mich.
Kung Shan-Chi, Laboratory, Campbell, Wyant & Cannon Foundry Co., Muskegon.

*Company Member.

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W. G. Hanawalt, Gen. Foreman, Belle City Malleable Iron Co., Racine, Wis.
Clarence Hansen, Core Room Foreman, Belle City Malleable Iron Co., Racine, Wis.
H. K. Leedy, Controlamix Co., Milwaukee.
Otto C. Ottoson, Met., Standard Foundry Co., Racine, Wis.
John Piacentine, Supt., Federal Malleable Co., West Allis, Wis.
***Pioneer Foundry Corp., Milwaukee.**
T. Earl Poulson, Cost & Methods Engr., Belle City Malleable Iron Co., Racine, Wis.
Charles Youngs, Sand Control, Belle City Malleable Iron Co., Racine, Wis.
A. N. Weberg, Pattern Foreman, Belle City Malleable Iron Co., Racine, Wis.

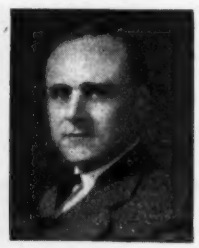
OUTSIDE OF CHAPTER

Juan L. Collignon, Pres.-Mgr., Cia. Mfra. de Artefactos Metalicos, S. A., Guadalajara, Jalisco, Mexico.
E. T. Evans, Jr., Chief Met., Elliott Co., Jeannette, Pa.
S. G. Harrison, Dir., Sykes & Harrison Ltd., Manchester, England.
R. E. Hinds, Foundry Foreman, National Bearing Div., American Brake Shoe Co., Meadville, Pa.
T. D. Lowndes, Supt., National Bearing Div., American Brake Shoe Co., Pittsburgh, Pa.
Ing. Enrique Molina P., Production Mgr., Fundicion "La Mexicana" S. A., San Pedro De Los Pinos, D.F. Mexico.
William G. Scott, Met., R. B. Tennent, Ltd., Coatbridge, Scotland.
K. H. Wright, Research Met., C. Akrill Ltd., West Bromwich, England.

Foundry Personalities

William T. Kelly, Jr., has been elected president of the Kellogg Div., American Brake Shoe Co. He has been executive vice-president of Kellogg since December, 1944.

C. E. Westover



W. T. Kelly, Jr.

John S. Hutchins has been elected president, Ramapo Ajax Div., American Brake Shoe Co. He has been associated with this organization for 20 years.

John A. Sterrett, president and general manager, Foundry Rubber Compounds Corp., Washington, D. C., recently announced the purchase from St. John X-ray Service, Long Island City, N. Y., their entire permanent mold and die casting business.

C. E. Westover and Jeff. Alan Westover have formed a new company, Westover Engineers, and are located in Milwaukee. This firm will exclusively serve the foundry industry on cost controls, occupational and job evaluation and wage incentive problems.

C. E. Westover has been associated with the foundry industry for the past 30 years. He has resigned his position with Grede Foundries, with whom he has been affiliated for the past 2 years. Previous to that he was Executive Vice-President and Treasurer of the American Foundrymen's Association.

Jeff. Alan Westover has resigned his position with Dyer Engineers, Inc., Cleveland, and has been doing industrial management work in foundries for the past 11 years. He has been active in Association activities and is a member of the Job Evaluation and Time Study Committee.

W. D. Bailey, Jr., has been named vice-president and general manager, Westlectric Castings, Inc., Los Angeles. **Edmund V. Linsenbard** has been made sales manager and **Alex Ross** has been appointed comptroller. **Ralph N. Schaper,** formerly works manager, Fort Pitt Steel Castings Co., McKeesport, Pa., has been added to the staff as assistant general manager, operating division.

Mr. Bailey is a past-president of the Southern California chapter, serving as president last year.

W. D. Bailey, Jr.

Aubrey M. Callis, formerly assistant general manager, Federated

(Concluded on Page 86)

CHAPTER OFFICERS

R. W. Griswold, Jr.
Griswold Mfg. Co.,
Erie, Pa.
Chairman
Northwestern Pennsylvania Chapter

J. J. McAntee
Covel Mfg. Co.,
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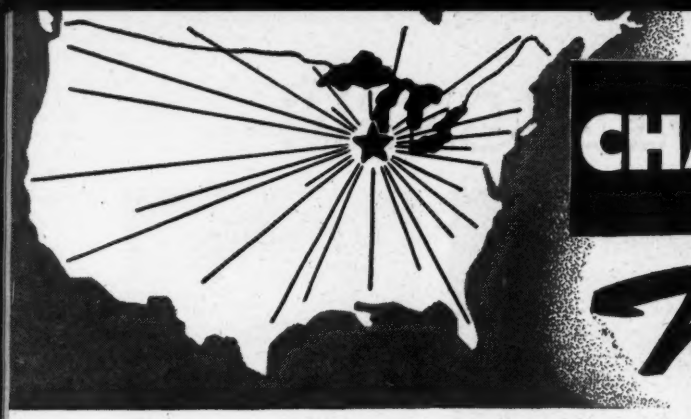
Vice-Chairman
Philadelphia Chapter



CHAPTER ACTIVITIES News

WISCONSIN CHAPTER
Starts Season with Group Meetings

By Walter Gerlinger, Walter Gerlinger, Inc., Milwaukee

A FIVE group sectional meeting was held by the Wisconsin chapter at the Schroeder Hotel, Milwaukee, September 14. John Bing, A. P. Green Fire Brick Co., Milwaukee, chapter chairman, presided over the meeting and introduced the various speakers and chairmen of the technical groups.

Malleable

At the malleable technical meeting, W. B. Sobers, Chain Belt Co., Milwaukee, discussed the development of an economical, reliable and flexible method for routine control analysis by applying colorimetric methods in conjunction with the combined method of chemical analysis for alloyed and unalloyed cast iron, malleable iron and steel. Steve Pohl, Federal Malleable Co., West Allis, Wis., acted as chairman and H. C. Stone, Belle City Malleable Iron Co., Racine, was co-chairman of this group.

Gray Iron

Frank Kulka, Motor Castings Co., Milwaukee, chairman of the gray iron group, introduced the four speakers of the evening at this session. The speakers were Ronald Webster and A. C. Den Breejen, Hydro-Blast Corp., Chicago; William A. Hambley and A. L. Stewart, Allis-Chalmers Mfg. Co., West Allis, Wis.

Mr. Hambley, the first speaker of the forum, began the discussion with an introduction to the subject "Sand Reclamation." In his remarks the two principle methods of reclaiming sand, the wet method and the thermal process, were noted. He concluded the first part of the discussion with these four leading questions: (1) Is it possible to reclaim sand?; (2) Is it practical to reclaim sand?; (3) Is is economical to reclaim sand?; (4) What is the smallest unit or foundry that can afford the process?

The second speaker, A. C. Den Breejen, answered Mr. Hambley's first question by stating that generally all sands can be reclaimed. Through a series of colored photomicrographs of sands taken from pits all over the country, Mr. Den Breejen pointed out the types of sand which were most desirable for reclaiming.

Ronald Webster referred to Mr. Hambley's third question stating that the savings resulting from sand reclamation depends largely on the

Overall view of the Southern California chapter's outing banquet.

plant using the equipment. Mr. Webster further emphasized, in answering the fourth question, that units operating on three tons per hour or 24 tons per day, were practical and economical. He also stated there is some hope to get the unit size down to a one-ton per hour basis.

Mr. Stewart briefly discussed the thermal process of sand reclamation. Although used successfully on low clay sands in aluminum and steel foundries, this work is still in the laboratory stage for gray iron foundries. In Mr. Stewart's opinion this method has good possibilities especially for the small foundry due to an estimated low installation cost.

Steel

The steel section meeting was started with a short talk by Sam Belis, Burnside Steel Foundry Co., Chicago, explaining the neck-down risers. The speaker illustrated his talk with a number of slides showing various foundry jobs before and after the neck-down risers were employed. S. Mueller, chairman of the steel group, The Falk Corp., Milwaukee, called on a group of foundrymen to answer questions pertaining to neck-down risers. A great deal of interest was stimulated and good discussion was brought forth.

Pattern

The Pattern Committee, under the chairmanship of A. F. Pfeiffer, Allis-Chalmers Mfg. Co., West Allis, Wis., had as their speaker William Elsner, Atlas Match Plate Co. His subject was "Pressure Cast Plate Demonstration." Also on the program for the pattern men was a movie on the elements of correct steel casting design.

Non-Ferrous

Two speakers participated at the non-ferrous group gathering which was presided over by Chairman John Wiltzius, Nordberg Mfg Co., Milwaukee. Nathan Janco, Centrifugal Castings Machine Co., Tulsa, Okla., spoke on centrifugal castings while John Putchinski, Allis-Chalmers Mfg. Co., West Allis, Wis., gave the latest developments in casting non-ferrous metals.

QUAD CITY CHAPTER REGIONAL CONFERENCE TENTATIVE PROGRAM

Hotel Blackhawk, Davenport, Iowa, Nov. 15-16, 1945

Thursday, November 15

9:00 a.m.—Registration.
10:00 a.m.—10:30 a.m.—Welcoming address.
Fred J. Walls, International Nickel Co., Detroit, A.F.A. National President.
"The Future of the Foundry Industry."
10:30 a.m.—12:00 noon—General Meeting.
(Speaker to be announced later.)
12:00 noon—Luncheon Meeting.
Speaker, L. J. Fletcher, Caterpillar Tractor Co., Peoria, Ill.
"Community Relations and Training in the Foundry."
2:00 p.m.—3:30 p.m.—Gray Iron, Malleable, Steel.
Speaker, Chas. Schureman, E. F. Schundler & Co., Joliet, Ill.
"Sand Control."
2:00 p.m.—3:30 p.m.—Non-Ferrous.
Speaker, W. B. George, R. Lavin & Sons, Chicago.
"Brass and Bronze."
3:40 p.m.—5:10 p.m.—Gray Iron.
Speaker, J. S. Vanick, International Nickel Co., New York.
"New Horizons for Cast Iron."
3:40 p.m.—5:10 p.m.—Malleable.
Round Table Meeting.
3:40 p.m.—5:10 p.m.—Non-Ferrous.
Aluminum and Magnesium.
6:30 p.m.—Banquet.
Speaker, Strickland Gillilan, Washington political observer, news analyst, author and lecturer.
"North of the Ears."

Friday, November 16

10:00 a.m.—11:50 a.m.—General meeting.
Speaker, J. A. Gitzen, Delta Oil Products Co., Milwaukee.
"Core and Mold Surface Coatings."
12:00 noon—Luncheon Meeting.
Speaker, Prof. Walter L. Daykin, College of Commerce, University of Iowa, Iowa City, Iowa.
"Modern Relationship between Top Management and Supervision."
2:00 p.m.—3:30 p.m.—Gray Iron.
Cupola Operation.
2:00 p.m.—3:30 p.m.—Malleable.
2:00 p.m.—3:30 p.m.—Steel.
Round Table Meeting.
2:00 p.m.—3:30 p.m.—Non-Ferrous.
3:40 p.m.—5:10 p.m.—General Meeting.
Centrifugal castings.

Tentative Program for Quad City Conference

By W. H. Sundeen,
Ordnance Steel Foundry Co.,
Moline, Ill.

THE Quad City chapter has announced a tentative program for its regional conference to be held in the Hotel Blackhawk, Davenport, Iowa, November 15-16. This conference, sponsored by the Quad City chapter, marks the renewal of regional conferences which were cancelled due to war-time restrictions. The chapter looks forward to a large attendance and is working hard to make this a successful event.

In the accompanying box will be found the tentative program for the conference.

Foundry Coke Interests Cincinnati Foundrymen

By Wm. H. Hoppenjans, Jr.,
Star Foundry Co., Covington, Ky.

OPENING the 1945-46 chapter season, the Cincinnati District chapter had for its first meeting B. P. Mulcahy, Citizens Gas and Coke Utilities, Indianapolis, Ind., as its first speaker. The meeting was held at the Engineering Society Headquarters, Monday evening, September 10. Approximately 75 members and guests assembled for the dinner and the chapter meeting, which was presided over by A. W. Schneble, The Advance Foundry Co., Dayton, Ohio.

The speaker chose as his subject foundry coke and devoted a considerable portion of his time to an exposition of the chemistry and mechanics of coke combustion in the foundry cupola. He also traced the evolution of coke from its original

form to the final product, and mentioned the many factors affecting its final characteristics.

A movie also was shown at this meeting entitled "Cupola Charging."

Magnuson and Ware on Coreblowing at St. Louis

By Lee H. Horneyer,
St. Louis

COREBLOWING was the theme for the St. Louis district chapter's meeting held September 13 at the DeSoto Hotel. The speakers, A. V. Magnuson, vice-president, Champion Foundry & Machine Co., Chicago, and J. Howard Ware, general sales manager, Redford Iron & Equipment Co., Detroit, explained coreblowing and demonstrated the blowing of various sizes and types of cores.

W. E. Illig, St. Louis district chapter chairman, Banner Iron Works, St. Louis, presided over the meeting and welcomed the 155 members and guests who attended. Short coffee talks were presented by Mr. Roth, Hadley Technical High School, St. Louis, and L. C. Farquhar, American Steel Foundries, East St. Louis, Ill.

Following the discussions presented by Messrs. Magnuson and Ware, a general question and answer period was staged. The great amount of interest shown throughout the meeting illustrated the importance of this subject and that the talks were appreciated by all those attending.

Foundry Problems Theme Of New England Meeting

By Merton A. Hosmer, President,
New England Foundrymen's Association,
Boston

OUTLINING the work that foundries have done during the war, and giving credit to the industry for the progress in mechanical and technical developments, Arthur J. Tuscany, Executive Secretary and Treasurer, Foundry Equipment Manufacturers Association, Cleveland, spoke on "Meeting Foundry Industry Problems and Suggestions for Meeting Them" at the first New England Foundrymen's Association meeting held at the Engineers Club, Boston, Wednesday, September 12.

Explaining that the principal need in the foundry today is a better method of merchandising their products, Mr. Tuscany stated that the merchandising problem would have to be attacked by the foundries themselves.

The speaker also showed a number of slides and gave a summary of a survey that the Foundry Equipment Manufacturers Association, made among 600 of the leading educational institutions in the country, with reference to their policies and plans for the future in regard to training foundry personnel.

Smith Relates China Foundry Experiences

By James B. Morey,
International Nickel Co.,
Los Angeles

SPICED with considerable humor, as well as pathos, and depicting the almost insurmountable problems

Whether it was golf, singing or wheelbarrow racing, everybody had fun at the Southern California chapter's stag party.

attending China's war effort, E. K. Smith addressed the Southern California chapter at their first meeting, held September 14, at the Elks Club, Los Angeles.

Addressing the membership on "Foundries in the Orient," the speaker used a number of slides made from his own personal photographs which he had taken during his year and a half stay in China. This added emphasis gave American foundrymen a most interesting sidelight on China's foundry practices and methods.

The meeting was presided over by Chapter President R. R. Haley, Advance Aluminum & Brass Co., Los Angeles.

Caldwell Addresses No. California on X-ray

By Geo. L. Kennard,
Northern California Foundrymen's Institute,
San Francisco

HOLDING its first meeting, the Northern California chapter met at the Engineers Club, San Francisco, on Thursday, September 6. Charles Hoehn, Jr., Enterprise Engine & Foundry Co., San Francisco, chapter president, was in charge at this initial session.

Speaker for the evening was T. E. Caldwell, assistant works metallurgist, Columbia Steel Co., Pittsburg, Calif., whose subject was "Foundry X-Ray Examination from the Metallurgical and Inspection Viewpoint." The speaker illustrated his subject very well by using slides and disclosed many interesting details that required considerable questioning and answering, following his lecture.

Annual Outing Held by Western New York Men

By Leo A. Merryman,
Tonawanda Iron Corp.,
Buffalo, N. Y.

THE annual outing of the Western New York chapter was held September 15, at Sturm's Grove, Buffalo, N. Y. More than 300 members and guests were present and participated in the many interesting games of skill provided for the entertainment of those present. Point scores were accumulated for each game, and in the evening prizes were distributed to the holders of the highest scores.

Food was served buffet style during the late afternoon and everyone commented that this outing was one of the best held.

Morton on Petroleum Castings at Houston

By R. B. Mumford,
McArdle Equipment Co.,
Houston, Texas

THE Texas chapter inaugurated the 1945-1946 season by a very successful and pleasant first fall meeting, attended by an overflow crowd, held at the Golfcrest Country Club, Houston, Texas, September 13.

A very interesting paper was given, with accompanying slides by B. B. Morton, International Nickel Co., on the application of castings in the petroleum industry. This was followed by a general group discussion.

Birmingham Features Picnic and Barbecue

J. P. McClendon,
Stockham Pipe Fittings Co.,
Birmingham, Ala.

ON Saturday, September 8, at the Roebuck Country Club, over 600 foundrymen and guests enjoyed the annual picnic sponsored by the Birmingham district chapter.

The day's program included golf, swimming, horseshoe pitching and softball. Two softball teams, picked at random, put on a game that was filled with spirit and enthusiasm. The contest was packed with spectacular plays and an occasional mis-

This year's annual Birmingham district chapter picnic attracted one of the largest crowds. Responsible for the success of the picnic was Picnic Chairman Charles B. Saunders, Woodward Iron Co., Woodward, Ala. (above, center). Others in the photograph are (left) A. O. Bruce, and (right) J. P. McClendon, Birmingham district chapter Publicity Chairman, both of Stockham Pipe Fittings Co., Birmingham.

A. Holberg, Birmingham District Chapter Membership Chairman.

cue. However, the game created widespread interest and attracted a good crowd.

The highlight of the day's activity was the barbecue that included all the delicacies that go to make up a successful picnic.

Winning battery of the Birmingham chapter's annual soft-ball game was (left) Herbert Strickland, catcher, and (right) Hugh Smith, pitcher. (Center) Frank Robinson was the umpire for the annual game.

Rochester Clam Bake Attracts Wide Interest

By Donald E. Webster,
American Laundry Machinery Co.,
Rochester

THE second annual Clam Bake of the Rochester chapter was held on Saturday, September 8, at the Point Pleasant Hotel on Irondequoit Bay. Over 225 attended this affair, and the chapter was honored to have various officials of the city government on hand. Other guests included members from the Western New York, Central New York and Northwestern Pennsylvania chapters.

A number of sporting events were staged during the afternoon and

prizes were awarded during the Clam Bake. Speed boats were available on the bay and proved very entertaining.

Martin Presents Motion Study Before Quad City

By W. H. Sundeen,
Ordnance Steel Foundry Co.,
Moline, Ill.

THE first meeting of the Quad City chapter was held September 17 at the Fort Armstrong Hotel, Rock Island, Ill., with 95 members and guests in attendance. Stuart Martin, Saginaw Malleable Iron Div., General Motors Corp., Saginaw, Mich., discussed "Better Methods in Motion Study." The highlight of the evening came when Mr. Shea, also from the Saginaw plant, put on a demonstration with Mr. Martin showing time saving methods and motions.

Southern Calif. Chapter Plans Educational Course

By James B. Morey,
International Nickel Co.,
Los Angeles

THE Educational Committee, Southern California chapter, under the chairmanship of John E. Wilson, Climax Molybdenum Co., Los Angeles, is planning an educational program on castings which will be given during the winter months. Five papers will be presented and will cover specifications, patterns, molds and cores, gating and risering practice, and the inspection and repair of ferrous and non-ferrous castings. Robert Gregg, Reliance Regulator Corp., Alhambra, Calif., is chairman of the Papers Committee.

Ceramic Society Renames Kraner to Sand Committee

THE American Ceramic Society Inc., Columbus, Ohio, has reappointed H. M. Kraner, Bethlehem Steel Co., Bethlehem, Pa., as that society's representative on the Executive Committee, American Foundrymen's Association Foundry Sand Research Project.

Over 200 members and guests, Western New York chapter, attended the Spring Dinner Dance at the Buffalo Trap and Field Club. *(Photos courtesy Jack Heysel, E. J. Woodison Co.)*

Chapter Meetings October-November

October 15
Twin City
Curtis Hotel
Minneapolis
B. L. Simpson
National Engineering Co.
"History of Casting Industry"

★ ★

October 18
Canton District
Mergus Restaurant
Canton
J. A. Rassenfoss
American Steel Foundries
"Some Notes on Manufacture, Design and Engineering Application of Castings"

★

Northern California
Mira Vista Country Club
Golf

★

Detroit
Engineering Society of Detroit
Group Roundtables

★ ★

October 22
Northwestern Pennsylvania
Moose Club
Erie
A. C. Den Breejen
Hydro-Blast Corp.
"Practical Foundry Sand Problems"

★

Central Ohio
Fort Hayes Hotel
Columbus
F. G. Sefing
International Nickel Co.
"Molding Methods for Sound Castings"

★ ★

October 23
Oregon
Heath Hotel
Portland
S. E. Peeler
Electric Steel Foundry
"Gates and Risers"

★ ★

October 25
Ontario
Royal York Hotel
Toronto
Group Meeting

October 26
Birmingham District
Tutwiler Hotel
Birmingham
J. S. Vanick
International Nickel Co.
"New Horizons for Cast Iron"

★

Chesapeake
Engineers Club
Baltimore
John Kane
American Air Filter Co.
"Dust Control"

★ ★

November 1
Saginaw Valley
Fischer Hotel, Frankenmuth, Mich.
F. G. Sefing
International Nickel Co.
"Molding Methods for Sound Castings"

★ ★

November 2
Western New York
Hotel Touraine, Buffalo
Round Table Discussions

★ ★

November 5
Central Indiana
Athenaeum
Indianapolis
E. C. Troy
Dodge Steel Co.
"Core and Molding Sands"

★

Chicago
Chicago Bar Association
Round Table Meeting

★ ★

November 6
Michiana
Hotel LaSalle
South Bend
E. H. Schleede
U. S. Gypsum Co.
"Pattern Making with Gypsum Cements"

★ ★

November 8
Northern California
Hotel Alameda
Alameda
"Refractories"

★

St. Louis District
Desoto Hotel
St. Louis
Dr. L. E. Hamlin
"Foundry Hygiene"

November 9
Philadelphia
Engineers Club
E. W. Horlebien
Gibson & Kirk Co.

★

Central New York
Hotel Onandaga, Syracuse
Walter Jaesche
Whiting Corp.
"Practical Points of Cupola Operation"

★

Eastern Canada and Newfoundland
Mount Royal Hotel
Montreal
Group Meetings

★ ★

November 9-10
Texas
Texas A. & M. College
Texas Station

★ ★

November 12
Cincinnati District
Engineering Society Headquarters
Cincinnati
Dr. S. W. Smith
Kelley-Koett Mfg. Co.
"X-ray as Applied to the Foundry Industry"

★ ★

November 13
Rochester
Hotel Seneca

★

No. Ill.-Sou. Wis.
Plant Visitation

★ ★

November 14-15
Quad City
Hotel Blackhawk
Davenport, Iowa
Regional Conference

★ ★

November 15
Detroit
Engineering Society of Detroit
"Producing, Designing and Buying Castings"

★ ★

November 20
Twin City
Curtis Hotel
Minneapolis
Fred J. Walls
International Nickel Co.
"Youth Encouragement"

★ ★

November 23
Chesapeake
Engineers Club
Baltimore
F. W. Hanson
Electro Metallurgical Co.
"Alloys in Gray Iron"

● COMMITTEE REPORT

REPORT ON
The Foundry Sand Research Project

By Technical Director H. Ries, Ithaca, N. Y.

IN spite of the pressure of work due to war conditions, most of our sand research committees have continued active during the past year.

The testing of sands at elevated temperatures has assumed such importance that it was found necessary to form three subcommittees, dealing with steel, iron and nonferrous sands, respectively, and the first of these subcommittees has been particularly active. The results of this work are appearing as reports of D. C. Williams, Sand Research Fellow.

Methods Being Developed

The Subcommittee on Physical Properties of Steel Foundry Sand at Elevated Temperatures has spent much time developing the proper methods of testing sand at elevated temperatures, and establishing the requisite conditions of testing and furnace construction to produce reliable, uniform and comparable results. It is surprising to find how many factors enter into the problem, and each must be given careful consideration. These high temperature tests are in some cases used for sand control work and in others for research experiments. It is to be hoped that they will be used more for the former when better understood.

The Committee on Grading and Fineness is giving attention to the method of expressing fineness by cumulative curves, instead of plotting individual percentages. It also is considering the use of the hydrometer for separating the constituents of the A.F.A. clay, which will be found to be of importance.

Another important property needing more attention is that of green deformation. Foundrymen have not given it much attention and have not realized its importance. They have sometimes complained of the inconsistent results obtained. W. G. Parker, chairman, Committee on Deformation, has devised a mechanism which makes the test more reliable, and his committee should have information of interest to present in the not distant future.

The Core Test Committee has a number of problems which it is investigating, such as warm strength and moisture absorption tests, collapsibility, core washes, core gas, etc. These have been assigned to subcommittees of the main committee and will be reported on at a later date.

The Light Metals Committee still has much work ahead of it studying first shop mixtures and their properties and perhaps special methods of testing. As Chairman Brewster states, references in the literature are quite old and scanty.

Another committee, that on Green Sand Properties, is studying the present tests on green sand to see what improvements in them may be necessary.

Two committees which have been inactive for the duration are those on Durability and Flowability. We are particularly in need of a standard and suitable method for testing the latter, as some foundrymen claim that existing suggested methods do not help them.

There is no doubt that the additional routine work imposed by the war has caused a slowing down in some cases of sand research. This is unfortunate, because there is still much to be done.

The Chairman finds that important and interesting work which has never been published has been done in some foundry laboratories, and it would be informative and of value if, when such results are obtained, they could be made public. In some cases this work involves tests which hitherto have not been generally tried.

The use of sand control has become widespread and foundrymen are appreciating it more and more. Cases are found where there is difficulty in applying it to foundry practice, but it should be emphasized that the tests should be carried out in accordance with instructions to obtain reliable results. Furthermore, the results obtained in these tests should be carefully checked with results obtained in the foundry.

French Foundrymen Plan To Visit U.S. Foundries

SEVERAL groups of French foundry executives are planning to visit castings plants in this country later this year in order to study American methods of production. Under the sponsorship of the Young Employers' Association of France, composed of younger business executives, a series of several privately organized tours now are being planned as a part of the reconstruction of the French industry.

Acting as "advance agent" for the contemplated visits is Paul De Rosiere, director general of the Creil Foundry, near Paris. The French group has indicated a desire to visit plants in the Cincinnati, St. Louis, Chicago, Detroit, Cleveland, and Philadelphia areas, and the A.F.A. chapters in those cities have been asked to assist in making arrangements for the tours. The end of the war left most French foundries in a deplorable condition as to efficiency and equipment, but with the realization that rehabilitation of all French industry depends largely on the foundries in that country, and their ability to produce castings at reasonable cost.

It is felt that the forthcoming visits of French foundry executives may prove excellent forerunners for French attendance at the 50th Anniversary Convention and Exhibit of A.F.A. to be held in Cleveland next May. In all probability, the 1946 annual meeting will be staged as an International Foundry Congress, and official invitations have been dispatched to European and other foundry groups to participate on an official basis.

Ampco Metal, Inc., Milwaukee 4, Wis., has produced an industrial motion picture, "Golden Horizons," illustrating the development of copper base alloys and the first discovery of copper by primitive man. This film is available for showing to schools and technical societies.

• COMMITTEE REPORT

CENTRIFUGAL CASTING

Committee Studies Casting Methods

By Chairman D. Basch, General Electric Co., Schenectady, N. Y.

THE Committee on Centrifugal Casting was constituted at the 1944 meeting of the A.F.A. Aluminum and Magnesium Division.

The task allotted to this committee was to investigate the possibilities of centrifugal casting light metals—aluminum and magnesium. Another duty involved obtaining for the light metals industry the same advantages that have accrued to such a large extent in steels, cast iron and the brasses.

At the first committee meeting, held in Cleveland, representatives of the foundry industry, suppliers, machine builders and presumptive consumers of light metal centrifugal castings were present. This meeting was called to obtain opinions and discuss new ideas.

Possibilities Evident

It became evident that the possibilities of light metals for centrifugal castings were quite definite, and that the advantages would be outstanding. No particular action was taken, but everybody was asked to collect whatever information was available and to formulate in their own mind some ideas as to how the work should be handled.

The second meeting took place in Detroit, and it soon became evident, in the discussion, that there was no agreement as to the basic principles to be followed. While there seemed to be agreement as to the feasibility of centrifugal casting of light metals, the ideas as to what must be done to produce centrifugal castings were widely divergent. Fortunately, the chairman had been able to lay his hands on confidential reports on centrifugal casting of light metals issued by the British Armament Research Department, which is the counterpart of the American War Metallurgy Board. The British apparently have done a tremendous amount of work in investigating the light metal centrifugal casting process and have been able to transform some very definite recommendations as to the best manufacturing routine using these light metals.

The English report claims that aluminum and magnesium can be cast centrifugally to be free from oxide inclusions and of a dense, fine grain structure without undue segregation. Also that the physical properties exceed those of ordinary sand castings and with yields, i.e., the ratio of net and gross weight, considerably above that of sand castings.

Use British Pattern

It was agreed that if the recommendations of the British Armament Research Department could be proven to be valid we would have a firm basis for further development. It was further decided to use a pattern corresponding, in the main, to the same design as that employed by the BARD. This pattern was to be used for test purposes, a certain number of castings in aluminum and magnesium following the manufacturing routine by the British.

The proposed casting is a wheel about 13-in. diameter, weighing about 20 lb. when made from aluminum, and is a combination of a centrifugal and a centrifuged casting.

A group of plants agreed to produce, in a vertical machine, three centrifugal castings each of the variations of the pattern. (The variations consisting simply in different thicknesses of the spokes connecting the hub of the casting to the rim.)

A similar group agreed to make the corresponding number of magnesium alloy centrifugal castings.

One plant agreed to make the same number of aluminum and magnesium castings in sand for comparison with the centrifugal castings.

Another plant decided to produce the same number of castings in permanent molds; while another undertook the production of magnesium castings in graphite (as the nearest approach to metal mold).

In order to make sure that all castings, whether made centrifugally or statically, use exactly the same metal, the aluminum and magnesium is to be taken from the same stockpiles. For a similar reason it was arranged with one concern to undertake the heat treating of all castings, and with another firm to do all the x-raying of the castings.

After heat treatment and x-raying, test bars will be cut out of each casting, at strategic locations, to determine tensile, yield strength and elongation. Analysis also will be taken at various points of the castings to investigate the changes in composition, segregation, etc. The physical testing has already been arranged for through the generous help of the committee members who have the testing equipment and personnel.

Grain size will be checked.

All data will be coordinated and finally evaluated by the plenary committee.

The job is progressing, the material has been distributed, patterns have been made, and we may expect castings in the not too far distant future.

Of course, under present conditions of manpower shortage and production demands the program cannot progress as fast as it would ordinarily. The interest in the program, however, seems to be so general and the advantages to be realized, both commercial and mechanical, so evident, that the work is actually progressing faster than we had expected.

Depending on the results of this basic program, further production routine development covering the broad scope of possible applications will have to follow.

Some Results

Some isolated tests run in the meantime have brought out the following points: (1) The yield of aluminum centrifugal castings is on the order of 70-80 per cent (higher in the case of stack molding) against about 25 per cent in sand. (2) The yield of magnesium centrifugal castings is again about 70-80 per cent (higher in the case of stack molding) against about 20 per cent in sand. (3) The fear of the danger of oxide inclusions in aluminum and magnesium due to the weight of aluminum and magnesium oxides compared with the base metal does not seem to be borne out by actual

tests. (4) Castings made so far indicate dense, fine grain structure with high physical properties. (5) Stack molding, i.e., stacking cores on top of each other with one common through sprue, seems to be quite feasible.

Acknowledgments

To the following the committee wishes to extend its thanks for the cooperation and time given in this study: Ford Motor Co. of Canada, Ltd., Windsor, Ont.; Naval Research Laboratory, Anacostia Station, Washington, D. C.; Shenango-Penn Mold Co., Dover, Ohio; General Electric Co., Schenectady, N. Y.; Michigan Light Alloys Corp., Grand Rapids, Mich.; Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.; Reynolds Metal Co., Springfield, Mass.; Maryland Sanitary Mfg. Corp., Baltimore, Md.; National Smelting Co., Cleveland; and Doehler-Jarvis Corp., Batavia, N. Y. The committee also desires to thank the Aluminum Co. of America, National Carbon Co. and Dow Chemical Co. for services rendered. The valued assistance of Peter Blackwood and John Perkins, Ford Motor Co. of Canada, Ltd., and C. E. Nelson, Dow Chemical Co., was greatly appreciated by the committee.

Veterans Receive Free ASM Refresher Course

RETURNING veterans who entered the service from the metal industry are offered an extensive program of free refresher courses by ASM.

According to W. H. Eisenman, ASM Secretary, the object of this course will be to bring the individual up-to-date on all new developments and processes that have taken place during his service. The specific phases of the industry of direct interest to the veterans will be emphasized.

The sixty-eight local ASM chapters are cooperating in this effort so that as much personal and specialized attention can be given the veteran as possible.

This service will be free and available to all veterans returning to the industry whether they are or are not ASM members. Requests for the course may be addressed to W. H. Eisenman, Secretary, American Society of Metals, 7301 Euclid Ave., Cleveland 3, Ohio. He will, in turn, see that the individual is referred to the ASM chapter nearest his location.

• COMMITTEE REPORT

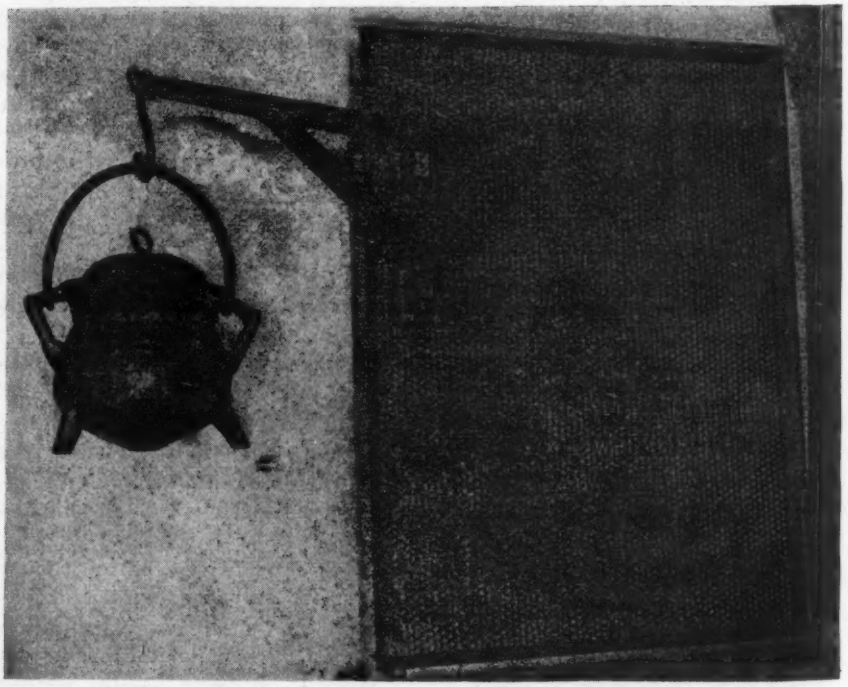
Cast Iron Committee Attains One Objective

By Chairman R. J. Allen, Worthington Pump & Machinery Corp., Harrison, N. J.

THE Committee on High Temperature Properties of Cast Iron (ASTM-ASME Boiler Code—War Metallurgy Committee, National Research Council) was organized in 1942 primarily for the purpose of collecting field application data on the performance of cast iron at elevated temperatures. First, to support a contemplated specification by the ASTM covering cast irons for use at temperatures up to and including 650° F., and, second, to cooperate with them in their endeavor to convince the ASME Boiler Code Committee that properly processed irons will stand up as satisfactorily at the higher temperature as it does at their present maximum of 450° F. The first objective has been attained; the second is at present in the process of development.

The work of the committee was simplified through the efforts of T. Barlow, then of the Vanadium Corp. of America, New York, and C. O. Burgess, Union Carbide and Carbon Research Labs., Niagara Falls, N. Y. These men, under the sponsorship of the War Metallurgy Committee, contacted many plants in different lines of industry and found many instances where cast iron, within its proper sphere of appreciation, has been functioning satisfactorily for many years at temperatures even above 650° F. Thus fortified, ASTM Subcommittee XXII of Committee A-3, under the guidance of J. S. Vanick, International Nickel Co., New York, has developed a specification covering cast iron for use in applications up to 650° F. which it is hoped will be adopted as a tentative standard. It is further hoped that the Boiler Code Committee may see fit later to approve the specifications and thus raise their restrictive limit from 450 to 650° F.

Having attained their first objective, the committee must wait to see whether or not the job has been sufficiently impressive to be accepted by others. The data collected through the War Metallurgy Committee survey has been summar-



Foundrymen have often raised the question: "What was the first casting ever made in an American foundry?" That can be answered by the above photograph showing the first casting made in America—a cast iron kettle.

ized in the May issue, AMERICAN FOUNDRYMAN, and is being further summarized in the Symposium on the Engineering Properties of Cast Iron. While awaiting the reaction to the ASTM Specification, the committee plans turning its attention to developing data on low temperature operations so that cast iron may satisfactorily retain, and possibly improve, its present position in the ever-growing air conditioning and refrigerating industries.

• COMMITTEE REPORT

Steel Foundry Sands Complete Busy Year

By Chairman Werner Finster,
Reading Steel Casting Div.,
American Chain & Cable Co.,
Reading, Pa.

DURING the past year the Subcommittee on Physical Properties of Steel Foundry Sands at Elevated Temperatures continued its work on three inter-related investigations. As a long range program the committee is investigating the effect of grain size, grain shape, various binders and moisture on properties at elevated temperatures. As this work aims at gaining fundamental information, only one variable can be changed at a time, thus requiring a great number of tests. In connection with this investigation Cornell University, Ithaca, N. Y., built a new furnace which is undergoing trial tests at present.

The program on check tests between four cooperating laboratories had to be held up temporarily until all four laboratories could install the new short post assembly on their dilatometers. At a meeting early in 1945, a detailed procedure for the next series of check tests was prepared. These tests have been made.

Very definite progress has been made in the Foundry and Mixtures program. A dilatometer was installed at Cornell University early in 1944. Green sand specimens from eight sand mixtures have been tested for hot compressive strength at 1600° F., 2000° F. and 2500° F. Results of these tests, which required the preparation and testing of over 1100 specimens, will be reported by D. C. Williams, A.F.A. Research Fellow, in the Fifth Progress Report.

A special Sub-Subcommittee under the chairmanship of Howard F. Taylor, Naval Research Laboratory, Anacosta Station, Washington, D. C., investigated the effect of rammer support on green strength and permeability. This report which describes several acceptable methods for supporting the rammer was completed in time to be included as Appendix III to the Fourth Progress Report, published in 1944 A.F.A. TRANSACTIONS.

The committee intends to continue the work on its three main projects, and hopes to gain sufficient information to be able to prepare tentative standards for test methods for determining physical properties at elevated temperatures.

Frederick B. Taylor, Montreal, Canada, by means of paint and canvas portrays men pouring bronze parts for anti-aircraft guns in a brass foundry of a Canadian war plant.

• COMMITTEE REPORT

Yield Strength Committee Finds Good Cooperation

By Chairman C. E. Nelson,
Dow Chemical Co.,
Midland, Mich.

THE purpose of the Committee on Yield Strength Investigation was as follows: (1) To consider the importance of yield strength in aluminum and magnesium castings with a view to noting whether full consideration is given this property by foundries, users, and design engineers; (2) To consider whether satisfactory means for yield strength testing are available; and (3) If deemed necessary, make recommendation of the proper action to acquaint the industries concerned with the importance of yield strength and/or approved methods for its determination.

Investigation and Results

As a result of discussions with a large number of individuals throughout the aluminum and magnesium industry, it became apparent that yield strength is presently being determined, and reported to customers, by all magnesium and most aluminum foundries. Further, most people were of the opinion that yield strength was pretty well recognized by engineers and made use of in the design of castings.

ANC-5, a handbook published by the Army and Navy on aircraft design criteria, lists minimum specifications on yield strength for practically all aluminum and magnesium casting alloys, and points out the significance of yield strength in design. Other handbooks provide similar information.

The ASTM has listed standard

methods for yield strength determination which are rapid and sufficiently accurate. Extensometers which may be quickly applied to the specimen are commercially available.

Conclusions

1. At the present time magnesium foundries and, to a large extent, aluminum foundries are determining yield strength and reporting it to customers.
2. Specifications and design manuals include yield strength and indicate its importance in design.
3. Adequate methods for accurate and rapid yield strength determination are known and widely used.

• COMMITTEE REPORT

Sand Courses Received Well by All Foundrymen

By Chairman Earl E. Woodliff, Detroit, and Co-Chairman Donald F. Sawtelle, Malleable Iron Fittings Co., Branford, Conn.

THE Sand Shop Operation Course meetings are a daily feature at each convention.

These meetings were, in their beginning and are still, founded upon the perpetual desire of the practical foundryman to learn what others are doing. Also it affords him the opportunity to discuss openly his problems with others so that he will receive helpful information. To attend these meetings and to learn what his fellow foundrymen are thinking and doing, keeps him posted on the latest developments.

Sand Important

Sand and molding materials occupy such a major place in the minds of operating foundrymen that their importance cannot be overlooked. This committee, in arranging for the Sand Shop Sessions, has continually tried to bring to these meetings men with experience in practical sand problems. These one-hour meetings provide a long discussion period. Sand Shop Operation Course sessions are opened by a short talk on a particular phase of foundry sand practice, the remaining portion of the meeting being given entirely to the sand problems of the visiting foundrymen and to their discussions of foundry sands and molding materials.

These meetings of the Sand Shop Operation Course are always well attended. The increasingly large attendance, from year to year, has merited a very favorable place upon the convention's program as evening meetings. To further make these meetings of greater value to all foundrymen, it is the plan to feature each session around sand problems pertaining to each of the various types of metals, both ferrous and non-ferrous.

• COMMITTEE REPORT

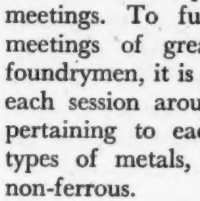
Foundry Cost Committee Helping Small Foundries

By Chairman R. L. Lee, Grede Foundries, Inc., Milwaukee

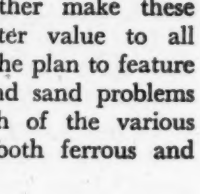
DURING the postwar period, competition between methods of fabrication will be exceedingly keen. The cast metals industry, during that period, will encounter competition, not only from other industries, but there also will be a great deal of competition within the in-

FOUNDRY PERSONALITIES

(Continued from page 74)



Dr. M. Siegel



A. M. Callis

Metals Division, American Smelting and Refining Co., Pacific coast department, has been appointed sales manager of the Whiting and Detroit plants with headquarters in Whiting, Ind.

Dr. Miguel Siegel, formerly chief of scientific service, head, foundry department, Instituto de Pesquisas Technologicas, Sao Paulo, Brazil, is now connected with Equipamentos Industriais "Eisa" Ltda. of Sao Paulo, Brazil, as technical director. Dr. Siegel will be located in New York for the next several months, after which he plans to return to Brazil.

H. J. French has resigned as assistant director for raw materials and facilities, steel division, War Production Board, Washington, D. C., and has resumed his duties as assistant manager, development and research division, International Nickel Co., Inc., New York.

O. J. Myers, formerly metallurgist, Wright Aeronautical Corp., Lockland, Ohio, is now director, foundry research, W. G. Smith Co., Cleveland.

Lloyd M. Joshel has been appointed general purchasing agent of the Velsicol Corp., Chicago.

Prof. Gilbert S. Schaller, mechanical engineering department and head of shop laboratories, University of Washington, Seattle, was a recent visitor at the National Office. He is a member of the Committee on Yield Strength Investigation, A.F.A. Aluminum and Magnesium Division.

R. W. Lindsay

R. W. Lindsay is now assistant professor of metallurgy, Pennsylvania State College, State College, Pa.

R. D. Wood Co. has moved its office in Philadelphia to 1072 Public Ledger Building, Independence Square, Philadelphia 5, Pa.

dustry itself. Sound competition is a healthy condition. Competition "by guess and by gosh," due to lack of knowledge of proper cost of product, is bad for the industry and can very easily lead to losses and bankruptcy, particularly among the smaller foundries.

In the past, smaller foundries have been handicapped in proper cost control because certain systems required more clerical help than the smaller foundry could afford. Realizing this, the Foundry Cost Committee is at present engaged in assembling a simple cost system for the small foundry employing less than 20 men, which can be used without any additional clerical help. After such a simple cost system is working, it can be added to or elaborated by use of the systems advocated by the different branches of the industry.

The Foundry Cost Committee has made considerable progress in preparing the system for the small foundry and expects to have it available later in the year. In addition, there are a number of questions of prime importance to the industry which will be covered by articles published in AMERICAN FOUNDRYMAN during the next few months.

• COMMITTEE REPORT

Chill Test Committee Seeks Test Cooperation

By Chairman T. E. Barlow,
Battelle Memorial Institute,
Columbus, Ohio

THE Committee on Chill Tests was established during 1944 for the purpose of studying the various methods of measuring chill as utilized by the gray iron foundry industry today. Particular emphasis was placed on the possibility of setting up tentative specifications for such a chill test on the principles that standardization of this well-known foundry tool would increase the possibility of interchange of valuable information; the same as the standardization of test bars has done. At the same time, it is hoped that definite relationships between the chill properties and the physical properties such as tensile strength, Brinell hardness, and transverse properties can be determined on the basis of a standard test procedure.

Since the presentation of the Chill Test Committee information at the 1944 Gray Iron Shop Course, the committee has prepared tentative specifications for a standard test, which will be presented to the industry in the very near future. These tentative standards will be submitted in the hope that foundrymen will utilize them and contact the committee in regard to their reactions to the type of test proposed. At the same time, the committee will set up a definite program of obtaining information which will help us to determine the relationship between the chill test and the properties of gray cast iron. It is impossible to say how soon such correlations can be completed, since it will depend, to a great extent, on the amount of cooperation that the committee receives from the foundry industry.

• COMMITTEE REPORT

Inoculation Committee To Publish Symposium

By Chairman T. E. Barlow,
Battelle Memorial Institute,
Columbus, Ohio

THE Committee on Inoculation was set up primarily to write a chapter in the ALLOY CAST IRON HANDBOOK incorporating the recent

NEW LITERATURE

Electro Refractories & Alloys Corp., Buffalo 2, N. Y., has prepared a catalog on cut-off and high speed grinding wheels and it is now available upon request.

American Air Filter Co., Inc., Louisville, Ky., has, upon request, a booklet describing the use of electronics in air filtration. The booklet is called "The Magic of Electronics in Air Filtration."

American Foundry Equipment Co., Mishawaka, Ind., has ready for mailing a 12-page illustrated booklet, Catalog No. 27, which gives data on three grades of blast nozzles.

The Applied Research Laboratories, 4336 San Fernando Road, Glendale 4, Calif., and the Harry W. Dietert Co., 9330 Roselawn, Detroit 4, Mich., now have ready for mailing a four page folder describing the new two-meter grating spectrograph.

A new bulletin describing an extensible-tip splice has been issued by the Manhattan Rubber Mfg. Division of Raybestos-Manhattan, Inc., Passaic, N. J. Copies may be obtained by requesting form No. 6861.

Dings Magnetic Separator Co., Milwaukee, has published a 32-page catalog describing electro-magnetic pulleys and pulley type separators.

Buffalo Foundry & Equipment Co., Buffalo 11, N. Y., has published a new equipment section to their chemical engineering catalog. It is available upon request.

A 40-page catalog illustrating benders is now available upon request through O'Neil-Irwin Manufacturing Co., Minneapolis 15.

The 4-page illustrated pamphlet, folder No. 2088, is now available through the Link-Belt Co., Chicago, describing an oscillating-trough conveyor.

A 32-page brochure prepared by Hercules Powder Co., Wilmington, Del., discusses the various uses of a pulverized resin binder for foundry use. Graphs and tables incorporated with this report give specific data on this binder when used with drying oils, coal tar pitch, reclaimed sand, silica flour and clay mixes.

J. J. Berliner and Staff, New York, has published a catalog of surveys which will be sent to interested clients upon request.

information on the subject of Inoculating Gray Cast Iron. When this activity was completed, however, the committee continued to function primarily as an organization for keeping in touch with recent developments, so that subsequent handbooks could be brought up to date with a minimum of effort.

During the past year, the Committee on Inoculation has been asked to prepare a symposium on the subject of Inoculation in Gray Cast Irons for presentation to the American Foundrymen's Association through the AMERICAN FOUNDRYMAN. This will be presented in future issues. This symposium will include papers by well-known authorities on the subject for the purpose of enlarging upon the information included in the ALLOY CAST IRON HANDBOOK. Any foundryman interested in the subject of inoculated gray cast irons is invited to prepare a paper on the subject for submission to the Committee on Inoculation for the symposium.

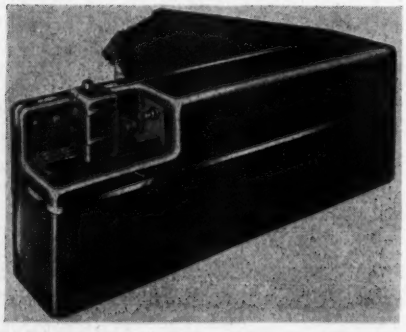
NEW EQUIPMENT

Two Meter Spectrograph

Harry Dietert Co., Detroit, has announced a two meter grating spectrograph designed for the analysis of high alloyed ferrous metals and other materials containing complex spectra, as well as for general research work.

Spectrograph can be supplied with two gratings; one which has 36,600 lines per inch or a second grating which has 24,400 lines per inch.

A 24 in. movable camera provides a 20 in. spectrogram on a 35 mm. spectrum film. The camera is movable on a radius arm allowing instantaneous photography in the regions from 1850-9200 angstroms. Two cameras also may be supplied for simultaneous photography of 40 in. of the spectrum. Eighteen spectra can be photographed on a single strip of film.



A two meter spectrograph.

Controls and camera are located at the same end of the instrument. A single control panel governs shutter timing, camera and aperture racking and grating door opening.

The instrument is so constructed that it is possible to enclose the camera side in a dark room.

The outside dimensions of the spectrograph are 8 ft. 9 in. by 6 ft. 6 in.

Bending Machine

O'Neil-Irwin Manufacturing Co., Minneapolis, Minn., has a redesigned and re-engineered bender for forming all ductile materials right on the job. Benders have greatly reduced operating friction due to the installation of roller bearings; a reversible lever control cam allows the operator a choice of either right or left hand forming direction.

A bender forming tubing.

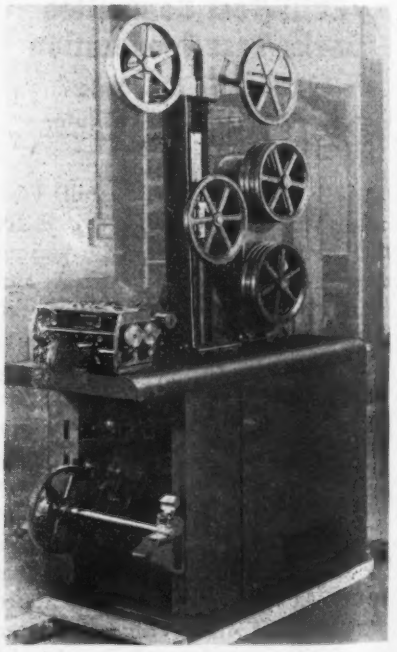
Pocket-Size Hand Hones

Bay State Abrasive Products Co., Westboro, Mass., announces two new pocket-size hand hones. Both models are available with a diamond section 7/16-in. wide by 1-in. and 1½-in. long with 1/16-in. depth diamonds. Supplied with plastic handles and handy leather pocket cases.

Pocket-size hand hones.

Wind-Up Machine

Industrial Oven Engineering Co., Cleveland, has developed a heavy-duty wind-up machine for the constant speed, constant tension winding of large diameter wire, cable, rope, hose and other continuous materials. It will handle flexible insulated wire and cable in diameters up to 1½ in. Standard speed ranges are 25 to 150, 40 to 200 and 60 to 240 ft. per min., and its tension values are from 5 to 1000 lbs. It is motor-driven and requires no outside source of power or synchronization. The standard model of the machine employs a 42 in. reel, but a special 60 in. reel can be supplied.



A heavy-duty wind-up machine for winding large diameter rope and cable.

(Continued on page 101)

THE LAST DROP IS AS GOOD AS THE FIRST

Ask the Men Who Use It!

I'll TAKE THE JOB WITH THE WHITE SIDEWALL TIRES!

Sure you will...if you can get it! And, one of these days you can be choosy about your new car. You can be choosy NOW ...about Core Oil...just ask for DAYTON OILS and be sure of getting the best in dependability and uniform quality. Don't take our word for it... ask one of your foundry friends... he's probably using DAYTON OILS!

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STEEL CORE AND MOLD WASHES - BINDER AND CORE PASTE - CORE WASHES - CHILL COATINGS

Abstracts

NOTE: The following references to articles dealing with the many phases of the foundry industry, have been prepared by the staff of *American Foundryman*, from current technical and trade publications.
When copies of the complete articles are desired, photostat copies may be obtained from the Engineering Societies Library, 29 W. 39th St., New York, N. Y.

Aluminum-Base Alloys

INSPECTION. *(See Metallography.)*

RECLAMATION. LaPelle, Rolland R., *"Remelting and Reclaiming Aluminum Scrap,"* ALUMINUM AND MAGNESIUM, July, 1945, vol. 1, no. 10, pp. 21-24.

Since the war the amount of aluminum scrap available has increased until it is now good economy to be able to reclaim this scrap. Various types of scrap are available. Easiest to handle is foundry scrap which consists of gates, sprues and risers, and occasionally defective castings. A second, or medium class of scrap consists of trimmings and punchings from light weight materials. A third type of scrap consists of turnings, sawings and other fine materials. A fourth type of scrap is that obtained from wrecked airplanes.

The important points in the reclamation of aluminum scrap are careful selection and segregation of various kinds of scrap, and careful melting, refining, and pouring.

The reclamation of wrecked aircraft parts presents special problems, since the scrap is apt to be contaminated with steel or copper-base alloys, and in most cases, the analysis of the metal prior to melting is unknown and must be determined.

In all probability the supply of aluminum scrap will be even greater after the war, and the ability to make use of it will be highly advantageous.

Clay

CONSTITUTION. Grimshaw, R. W., and Roberts, A. L., *"An Investigation of the Constitution of Certain Foundry Bonding Clays,"* FOUNDRY TRADE JOURNAL, July 19, 1945, vol. 76, no. 1509, pp. 233-238.

In an investigation to determine the nature of the principal mineral constituents of certain clays, the mineral constituents were identified by thermal analysis, supplemented by microscopic examination, rehydration studies, and density measurements.

A careful study of the constitution of Colbond revealed that it contained approximately 40 per cent of a kaolinite-group mineral, 31 per cent quartz, and the balance of various accessory materials.

Converter Practice

CONTROL. Jazsinski, S. T., *"The Control of Tropenas-Converter Blowing by a Direct-Vision Spectroscope,"* Advance Copy, JOURNAL OF THE IRON AND STEEL INSTITUTE, June, 1945, 4 pp.

The development of a converter flame during the blow and the appearance and disappearance of certain lines of the spectrum observed through the direct-vision spectroscope are described. No attempt was made in these preliminary investigations to measure the wave-lengths of the bands, only their relative positions being recorded.

A very faint continuous spectrum appeared at the beginning of the blow and grew stronger as the flame became brighter. The most pronounced yellow band appeared when boiling began; when ejects ceased a green band, faint at first, appeared. During the carbon flame two other green bands and two red bands became visible. At times a blue band was discernible. When all bands disappeared the wind was shut off.

The real value of this lies in the possibility of controlling the converter blow without introducing the human factor, and the consequent elimination of over and under-blown heats. The disappearance of the red, green, and yellow bands is an indication that the blow is finished and the carbon near 0.1 per cent. If the wind is not shut off when the bands disappear, the heat becomes overblown, with consequent low carbon content, higher losses of metal due to oxidation, and excessive wear on the lining.

The conclusions point to a very definite relationship between the bands in the flame spectrum and the composition of the metal in the bath. This leads directly to the application of the "electric eye" to the Tropenas converter to attempt a more rigid control of the process.

Cupola Practice

AIR SUPPLY. Pinchin, H., *"The Problem of the Measurement of Cupola Air Supply,"* FOUNDRY TRADE JOURNAL, July 12, 1945, vol. 76, no. 1508, p. 219.

The air supply to a cupola is most frequently measured by instruments which are located in the piping between the blower and the cupola. This is unfortunate, however, since the nature of the instruments is such that they only function well when located in a long, straight stretch of piping which insures undisturbed flow and eliminates all turbulence.

The author points out that this problem can usually be solved by locating the measuring instruments at the inlet side of the fan, where it is nearly always feasible to set up a straight length of pipe in which the instruments can be installed.

Furnaces

ATMOSPHERES. *(See Heat Treating.)*

MAGNESIUM HEAT TREATING. Keller, A. V., *"Furnaces and Heat Treatment for Permanent Mold Magnesium Castings,"* MODERN METALS, August, 1945, vol. 1, no. 7, pp. 20-21, 23.

In this article the author describes the construction and operation of a heat treating furnace for magnesium-base alloy permanent mold castings.

In addition to the furnace construction, the author describes the furnace load, how the furnace atmosphere was controlled, and how certain typical casting defects were controlled. In tabular form he gives the full heat treating cycle and the properties of metal in various conditions.

OPENHEARTH. *(See Steel.)*

Gray Cast Iron

IMPACT TESTS. Everest, A. B., Grant, J. W., and Morrogh, H., *"The Development of a Single-Blow Impact Test for Cast Iron,"* Advance Copy, JOURNAL OF THE IRON AND STEEL INSTITUTE, June, 1945, 21 pp.

Applications of modern high-duty cast iron in the Services and in engineering practice generally often call for a measure of shock resistance, and the need has been felt for some time past for a simple test to evaluate this quality. A sub-committee of the Technical Advisory Panel to the Directors for Iron Castings, Ministry of Supply, was therefore set up to collaborate with the British Cast Iron Research Association in reviewing the work previously carried out in this field and to explore the possibilities of standardizing a suitable test. After reviewing previous work it was decided that the Izod form of test offered the best possibilities and had the further advantage that suitable machines were widely available.

The small test-piece, standard for steel, however, is useless for cast iron, owing to its relatively low impact value. Tests were put in hand, therefore, using larger test-pieces, with and without notches or grooves. Selected forms of test-piece were distributed to various investigators and the consistency of the results obtained on standard grades of cast iron was studied. Whilst a satisfactory range of values has been established, unfortunately discrepancies between different machines and the variation in results due to the normal heterogeneity of cast iron have led to a scatter of results which up to the present does not justify final standardization. A recommended procedure, however, has been evolved and is now in regular use by a number of investigators for a period of time prior to further consideration with a view to its possible ultimate standardization.

Peculiarities of the test on cast iron

(Abstracts continued on page 98)

They "had to be shown"...

RADIOGRAPHY teaches sound practice...rejections tumble 66⅔%

BASED primarily on a foundry experience, this case history applies to *all* industry, for product quality demands suitable methods of production, and instruction is a widespread problem.

In this particular case, customer rejections were running 45%. Yet to the workmen the returned castings looked perfect. But metallurgical investigation, with radiographs of the internal structure, revealed unacceptably large grain size—due to improper pouring temperatures. The findings were passed on to the foundry.

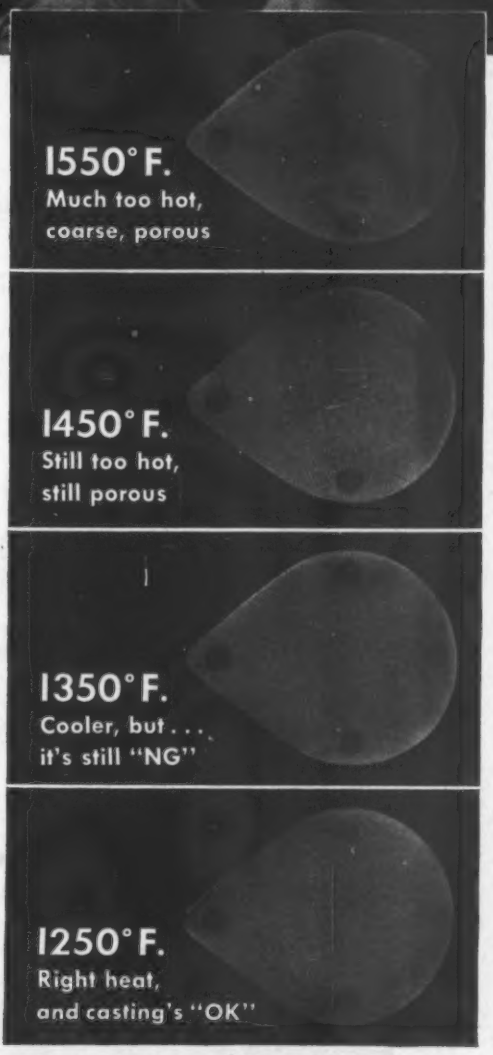
Believing the workmen needed only "to be shown," 4 melts were poured in one day—each at a higher temperature—and radiographed to show exactly what happened inside the metal . . .

First melt, poured at 1250°F., was clearly acceptable . . . had a fine grain structure. Additional melts, poured at 1350° F., 1450° F., and 1550° F., were increasingly grainy and porous . . . indicating graphically why rejections had reached 45% of production totals. Convinced, the workmen adopted the satisfactory 1250° F. pouring temperature as standard. Rejections dropped to less than 15%—an immediate improvement of 66⅔%.

The story is food for thought, indicates the versatility of industrial x-ray. For radiography is more than an inspector of internal conditions . . . it's a teacher . . . a "prover," too. Engineers and designers in all fields use radiography to obtain basic information leading to better products . . . streamlined operations.

Radiography's success suggests it as an absolute "must" in the keen competition ahead. Investigate its possibilities in your plant. See your local x-ray equipment dealer. Do it now.

EASTMAN KODAK COMPANY, X-ray Division, Rochester 4, N. Y.



STEP BY STEP—at temperature intervals of 100° F.—these melts were poured and x-rayed. Range of graininess and porosity is clear and proves definitely the correct heat for pouring sound castings.

RADIOGRAPHY

ANALYZES . . . INSTRUCTS . . . CORRECTS . . . IMPROVES

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The peace for which we all yearned is here!
Once again we gladly produce for Church, School, Farm and Industry.
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GREAT LAKES

OTTAWA WHITE

Silica Sands

WASHED DRIED SCREENED

for... **MOLDS**—*Base sands for synthetic molding*
CORES—*Silica core sand of many grades*
SANDSLINGERS—*Free flowing—High permeability—Ideal finish*
FINE AND COARSE SANDBLAST SAND
FURNACE BOTTOMS
GROUND SILICA (FLOUR)

- Molding Sands
- Juniata Bank Sands
- Indiana Bank Sand
- Lake Core Sands
- Ottawa Silica Sands
- Crude Silica Sands
- Diamond Blast Sand
- Flint Shot Blast Sand
- Gold Jacket Blast Sand
- Muscatine Blast Sand
- Steel Shot & Grit
- Stoody Borium Nozzles
- Bentonite (Volclay & Southern)
- Rebonding Clays
- Refracto Fire Clays
- A.B.C. Foundry Coke
- Fire Brick
- Firestone (Sawed & Rough)
- Mica Schist—Grits
- Ganister (Firegan)
- Limestone—Dolomite
- Fluorspar
- De-Sul-Flux
- Chrome Ore
- Nepheline Syenite

GREAT LAKES Silica Sands are screened so as to insure uniformity of grain fineness, car after car, resulting in maximum permeability.

GREAT LAKES Silica Sands are shipped in paper-lined box cars to insure arrival at your plant moisture free and ready for use.

GREAT LAKES Ottawa white sands are pure silica, having been washed and rinsed free of all clay substance in pure artesian, lime-free water.

GREAT LAKES Silica Sand orders are filled promptly—Advance shipping schedules rigidly adhered to—Ample rail facilities and three modern mills to serve you.

GREAT LAKES pioneered in supplying the foundry industry Silica Sand,—A.F.A. grades ranging from 25 to 85 grain fineness, and the services of an expert technical staff to service the use of our sands. These foundry trained men are constantly at work in completely equipped sand laboratories to improve the grading and testing of sands to meet the exacting requirements of modern foundry practice.

Great Lakes Foundry Sand Co. UNITED ARTISTS BLDG. DETROIT, MICH

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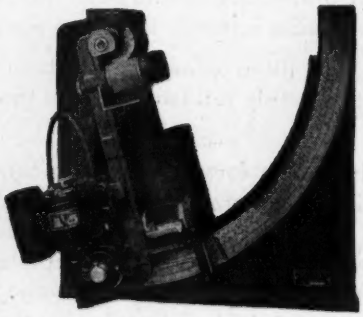

The universal sand strength machine with motor drive provides a strength testing machine for the laboratory that will perform a large variety of strength tests on molding sand, clays, cores and core paste. A sturdy and reliable unit from which accurate results may be obtained with the least amount of effort.

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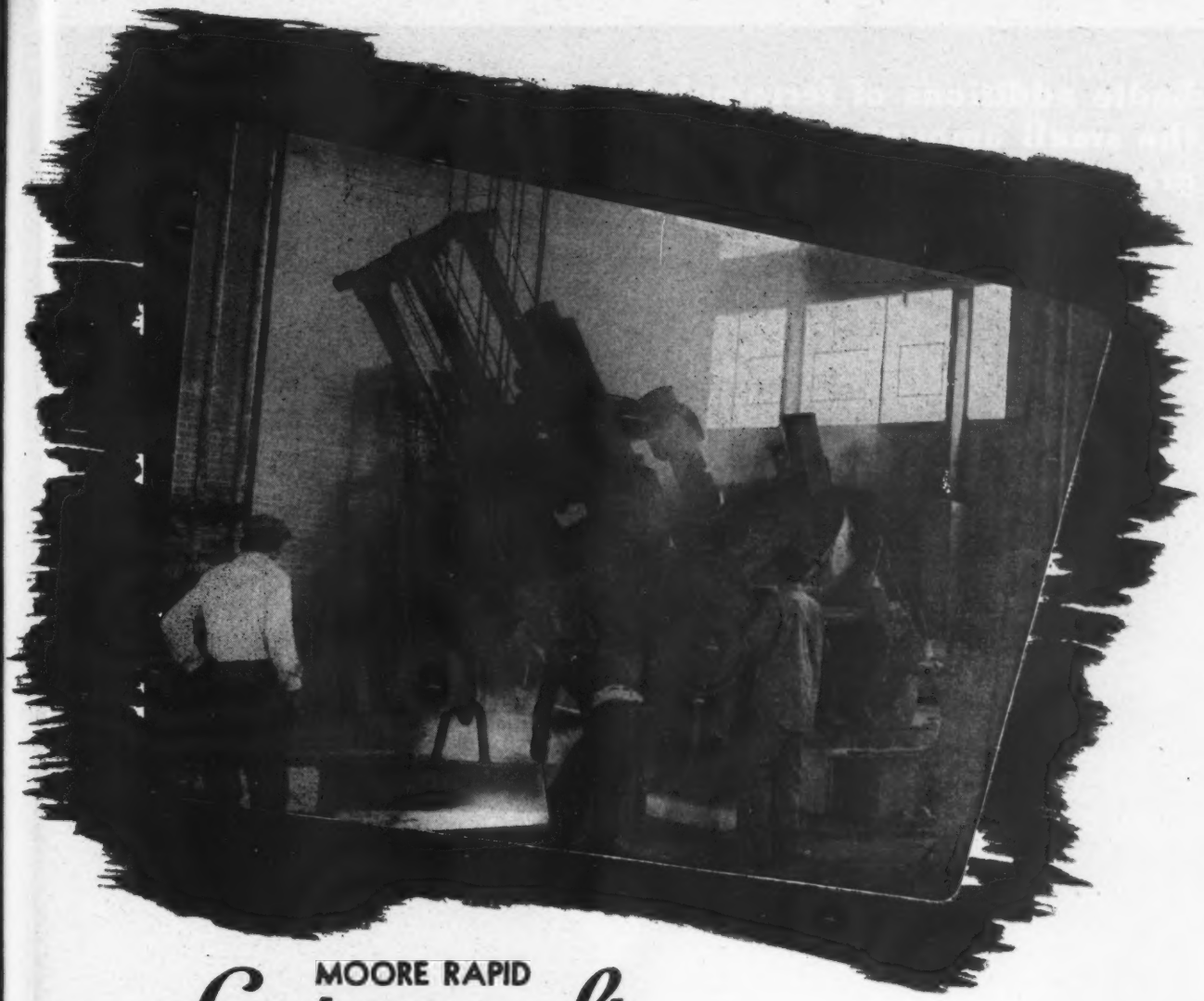

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(e) Usual KVA rating	2000 to 2500
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(g) Shipping weight—2 linings and 50 electrodes (approximately)	42 tons
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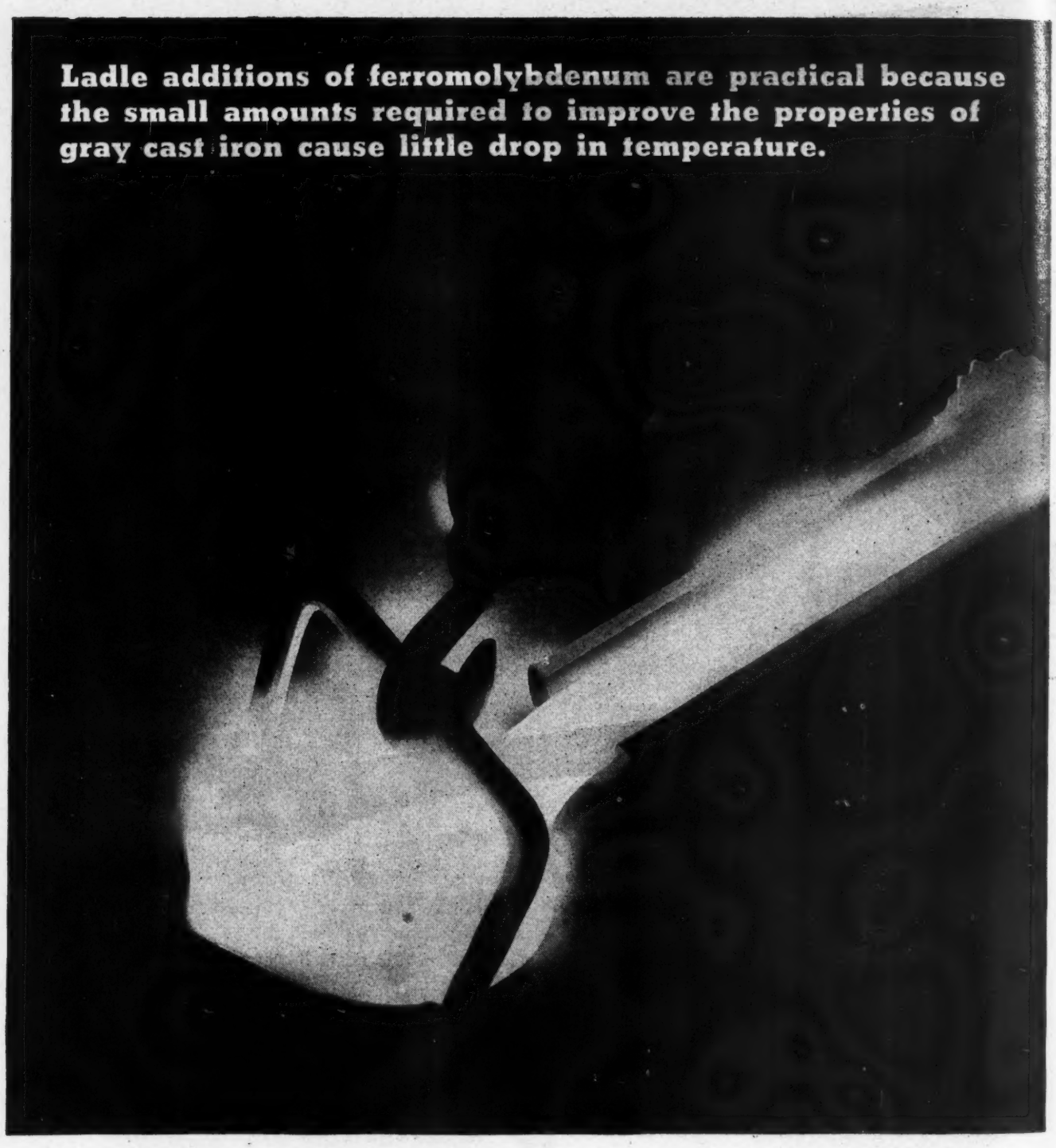

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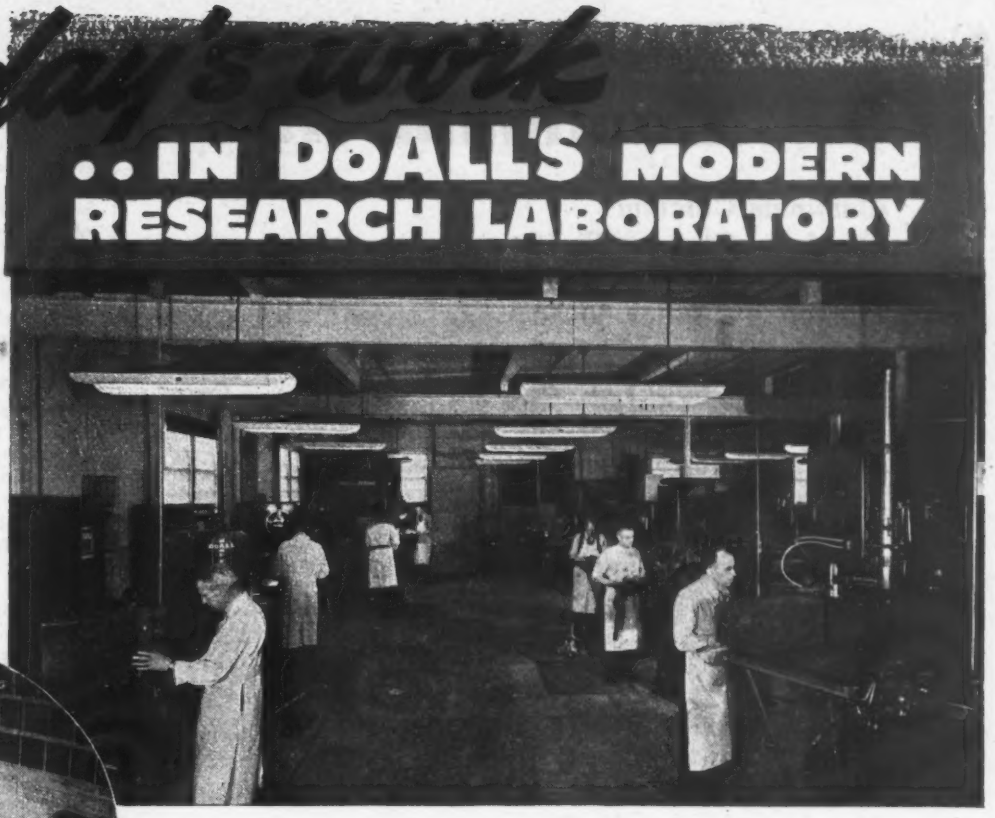

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Aluminum Magnesium 90/10
Aluminum Magnesium 98/2
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Aluminum Manganese 80/20
Aluminum Manganese 90/10
Aluminum Manganese 95/5
Aluminum Manganese, Metallurgical Grade
Aluminum Nickel 80/20
Aluminum Nickel Copper 50/25/25
Aluminum Shot
Aluminum Silicon 50/50
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BUFFALO 17, NEW YORK

ABSTRACTS

(Abstracts continued from p. 90)

exist, such as the double-blow effect, whereby the broken part of the specimen shows frequently two or more impressions of the knife-edge. This phenomenon has been studied in detail and the mechanism of the double-blow effect finally established by a high-speed photographic record of the test in progress. Other variables have also been studied with a view to their elimination as possible disturbing factors in the test.

Heat Treating

ATMOSPHERES. Peck, C. E., *"Application of Controlled Atmospheres to the Processing of Metals,"* TRANSACTIONS OF THE A.S.M.E., August, 1945, vol. 67, no. 6, pp. 501-512.

The development and application of separately controlled atmospheres for use in conjunction with heat-treating processes has been rapid during recent years. By means of controlled atmospheres, finished machine parts which require heat-treatment can be processed without loss of surface hardness during heating, and without further grinding or cleaning. Many other applications in the treatment of metals, such as welding, forging, melting, sintering, and the like, are possible although at present somewhat limited. This paper outlines the principal types of atmospheres and describes briefly the equipment available for producing these atmospheres. A summary is given of the application of these atmospheres to a wide variety of heat-treating processes now in active commercial use.

Impact Tests

SINGLE BLOW. *(See Gray Cast Iron.)*

Magnesium-Base Alloys

HEAT TREATING FURNACES. *(See Furnaces.)*

METALLURGY. Carapella, Louis A., *"Fundamental Alloying Nature of Magnesium,"* METAL PROGRESS, August, 1945, vol. 48, no. 2, pp. 297-307.

Data on many magnesium alloy systems were considered in studying the alloying nature of magnesium. It was found that such factors as crystal structure, atomic size, alloying valence, and electrochemical nature had notable effects on the liquidus, solidus, and solid solubility curves of equilibrium diagrams. Most susceptible to these effects were the solidus and the solid solubility curves.

Among the diagrams and tables is an up-to-date tabulation of pertinent data on binary systems of magnesium.

A selected bibliography follows the article.

SPECIFIC APPLICATIONS. Cristello, Anthony, *"The Gating of a Large Magnesium Casting,"* ALUMINUM AND MAGNESIUM, July, 1945, vol. 1, no. 10, pp. 18-20.

The author tells how the gating and chilling methods were developed for a large magnesium casting having special requirements.

Mechanical Handling

FOUNDRY. *"Foundry Mechanization,"* MECHANICAL HANDLING, August, 1945, vol. 32, no. 8, pp. 429-438.

The article describes how a greatly in-

creased output was attained at the foundry at Humber Ltd., by the installation of mechanical handling equipment.

Metallography

ALUMINUM-BASE ALLOYS. *"Metallography, A Light Metal Inspection Tool,"* LIGHT METAL AGE, August, 1945, vol. 3, no. 8, pp. 17-19.

The advantages offered by metallographic inspection as a control of die casting quality are discussed and summarized in this article. In addition the qualifications of a metallographer, metallographic techniques, the equipment necessary for installtion of a metallographic laboratory, and concrete applications of this type of inspection are considered.

Metal Pouring

RADIOGRAPHIC OBSERVATION. Fry, S. L., *"Preliminary Investigation of Metal Pouring by Cine Radiography,"* FOUNDRY TRADE JOURNAL, July 12, 1945, vol. 76, no. 1508, pp. 213-216; July 19, vol. 76, no. 1509, pp. 239-244.

How metal behaves when poured into a mold and during solidification was observed by pouring metal into a mold positioned between an x-ray tube and a fluoroscopic screen and photographing the screen with a Cine camera. Special equipment was constructed to accommodate the x-ray tube, mold, and screen. The camera was run at 16 frames per second until the mold was completely filled; from then until solidification was complete, individual exposures were made at intervals of 10 seconds in an attempt to observe the formation of gas bubbles and shrinkage cavities.

The second installment of this article reproduces the series of cinegraphs taker in this investigation.

Molding Materials

CORE PAINTS AND WASHES. Rees, W. J., *"Mould and Core Paints and Washes and Parting Powders,"* THE REFRACTORIES JOURNAL, July, 1945, no. 7 (21st year), pp. 266-269.

The inception of the investigation on non-siliceous alternatives to silica flour for parting powders and mould and core paints is described. Alternatives to silica flour for parting powders which are quite satisfactory in foundry use are indicated. The trials made with mould and core paints indicate that silica flour can be satisfactorily replaced by non-siliceous materials. Calcined ball clay or aluminous fireclay is satisfactory for small and medium steel castings; for larger castings sillimanite, calcined or fused alumina, and zircon have given satisfactory results. The choice of the most suitable alternative depends on the particular condition of foundry practice.

Parting Materials

SILICIA FLOUR. *(See Molding Materials.)*

Radiography

DUPLICATE RADIOGRAPHS. Herbein, Stuart D., and McKenna, James F., Jr., *"A Simple Method for Producing Duplicate Radiographs,"* INDUSTRIAL RADIOGRAPHY, Summer Number, 1945, vol. 4, no. 1, p. 28.

A so-called light reversal process permits the making of sharp and sensitive duplicates of radiographs by means of a single printing operation and the use of a special type of film.

FUNDAMENTALS. Evans, Maynard B., *"Technique and Terminology Highlights,"* INDUSTRIAL RADIOGRAPHY, Summer Number, 1945, vol. 4, no. 1, pp. 18-25.

The author has outlined the fundamentals of radiographic technique.

MICROGRAPHY. Ball, Leslie W., *"X-ray Micrography As a Tool for Foundry Control,"* INDUSTRIAL RADIOGRAPHY, Summer Number, 1945, vol. 4, no. 1, pp. 29-36.

This paper briefly traces the use of x-ray micrography and shows that with the proper equipment and technique the procedure can be simplified. The paper shows that microcavities can be studied in sufficient detail to enable their proper diagnosis and correction.

The paper also shows that an identification library of radiographs together with corresponding micrographs can be provided to assist X-ray interpreters in making decisions regarding castings.

Sand

GRAIN SHAPE. Davies, W., and Rees, W. J., *"The Effect of Grain Shape on the Moulding Properties of Synthetic Moulding Sands,"* THE REFRACTORIES JOURNAL, March, 1945, no. 3 (21st year), pp. 98-118.

From a study of the correlation of grain shape and properties of synthetic

(Continued on page 101)

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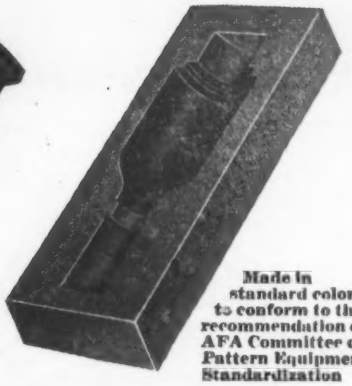

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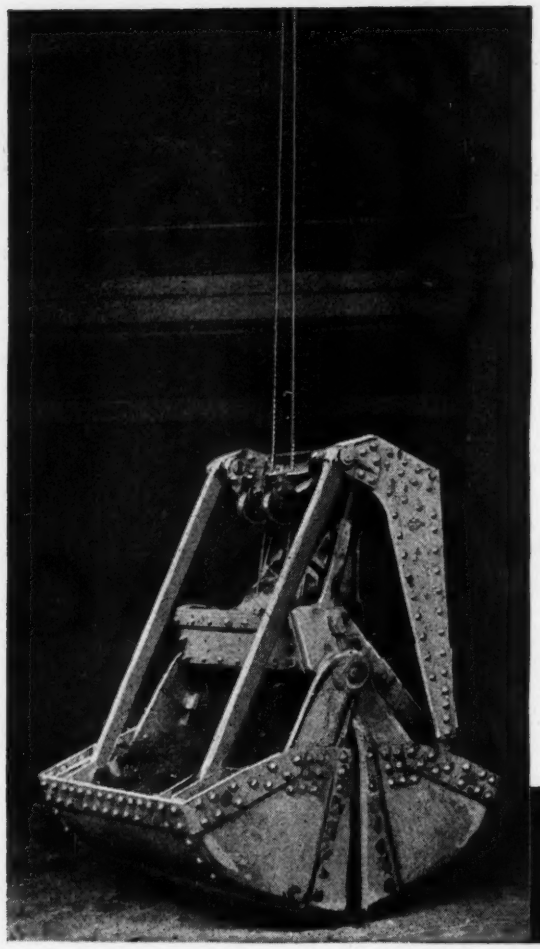

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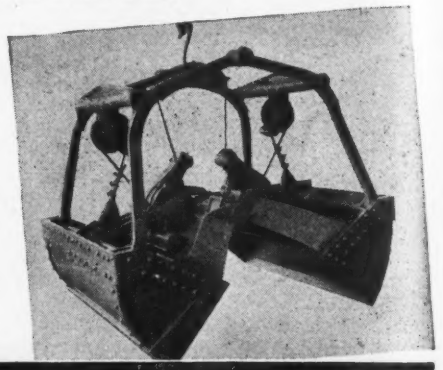

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American Foundrymen's Association

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ABSTRACTS

(Continued from page 99)

sand mixtures, the authors have concluded that angular sands have molding properties inferior to those of rounded sands, which is due partly to their greater bulk-density gradients and partly to the difference in grain relationships.

Differences in strength are due primarily to grain shape and not to specific surface. If bond is added to two similarly graded sands in proportion to their specific surfaces, the more angular sand will still have a much lower strength than the more rounded sand.

Scrap

BRIQUETTING. Jbankov, N. A., *"Engineer Vailiev's Electro-Briquetting Machine,"* FOUNDRY TRADE JOURNAL, July 12, 1945, vol. 76, no. 1508, pp. 221-222.

A description of a briquetting machine which simultaneously compresses and electrically heats the briquetting material with the same set of dies. The combined compressing and heating action softens the metal sufficiently to permit welding and caking.

Steel

OPEN HEARTH OPERATION. Work, H. K., and Webb, W. R., *"Operation of 4-Ton Openhearth,"* THE IRON AGE, August 2, 1945, vol. 156, no. 5, pp. 42-47.

Construction and operating characteristics of an experimental 4-ton openhearth furnace which has produced over 2100 tons of plain, medium, and high-carbon steels, free-cutting steels, and high-alloy-containing steels. Successive modifications of the original design are traced, and the reasons for the various alternations presented. The value of such a furnace as a research and development tool is discussed.

Washes

CORE. *(See Molding Materials.)*

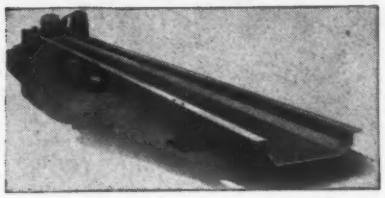
NEW EQUIPMENT

(Continued from page 88)

Oscillating-Trough Conveyor

Link-Belt Co., Chicago, announces an oscillating-trough conveyor for handling sharp, jagged, abrasive, wet, oily or hot material. The conveyor consists of a flexibly supported plate steel trough of rectangular cross-section, which is oscillated back and forth by an eccentric drive at a speed that will result in a forward travel movement of 20 to 50 feet per minute for most materials, depending on the flowability of the material being handled.

The conveyor is designed in two types, the short hanger and long hanger. The short hanger construction permits installation of the conveyor in a shallow trench along the floor of a machine shop for the handling of metal turnings, borings, and other machine shop waste.



An oscillating-trough conveyor of the short hanger type.

The long hanger construction is recommended where trough tunnels below conveyor are permissible or where it is possible to floor-mount the conveyor.

Die Casting Machine

Light Metal Machinery, Inc., Erie, Pa., is building a die casting machine for the production of small zinc, tin and lead alloys. It is completely automatic and has four operating speeds. The machine is small, but compact, and can be operated in a

(Continued on page 102)

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Chicago, Ill.	Wehenn Abrasive Co.
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Coldwater, Mich.	The Foundries Materials Co.
Detroit, Mich.	The Foundries Materials Co.
Dallas, Texas	Barada & Page, Inc.
Edwardsville, Ill.	Midwest Foundry Supply Co.
Hammond, Ind.	The Foundries Materials Co.
Houston, Texas	Barada & Page, Inc.
Kansas City, Mo.	Barada & Page, Inc.
Long Island City, N.Y.	F. E. Schundler & Co., Inc.
Los Angeles, Calif.	Ind. Fdy. Supply Co.
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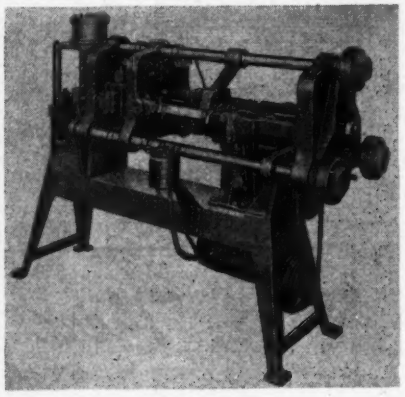
NEW EQUIPMENT

(Continued from page 101)

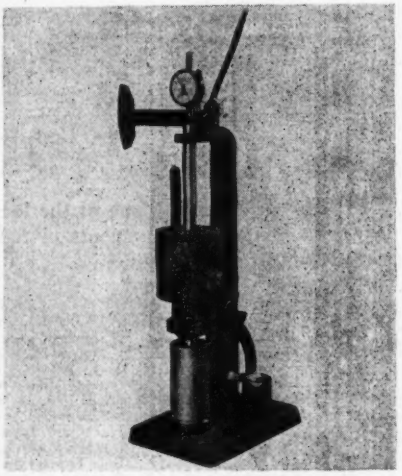
space of 100 ft. square. The machine is 6 ft. long, 21 in. wide, 4 ft. 6 in. high and weighs 3,000 lbs.



A die casting machine for producing small alloy products.

Sand Rammer

Harry W. Dietert Co., Detroit, has built a new sand rammer for ramming 2 in. x 2 in. sand specimens. Improvements incorporated in this sand rammer are many and include a flowability and moisture indicator and is modern designed.



Sand rammer for ramming 2 in. x 2 in. sand specimens.

Utility Set

Bay State Abrasive Products Co., Westboro, Mass., has a new compact package of 12 mounted wheels and points in sizes mostly commonly used.

(Concluded on page 104)

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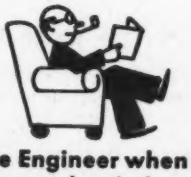

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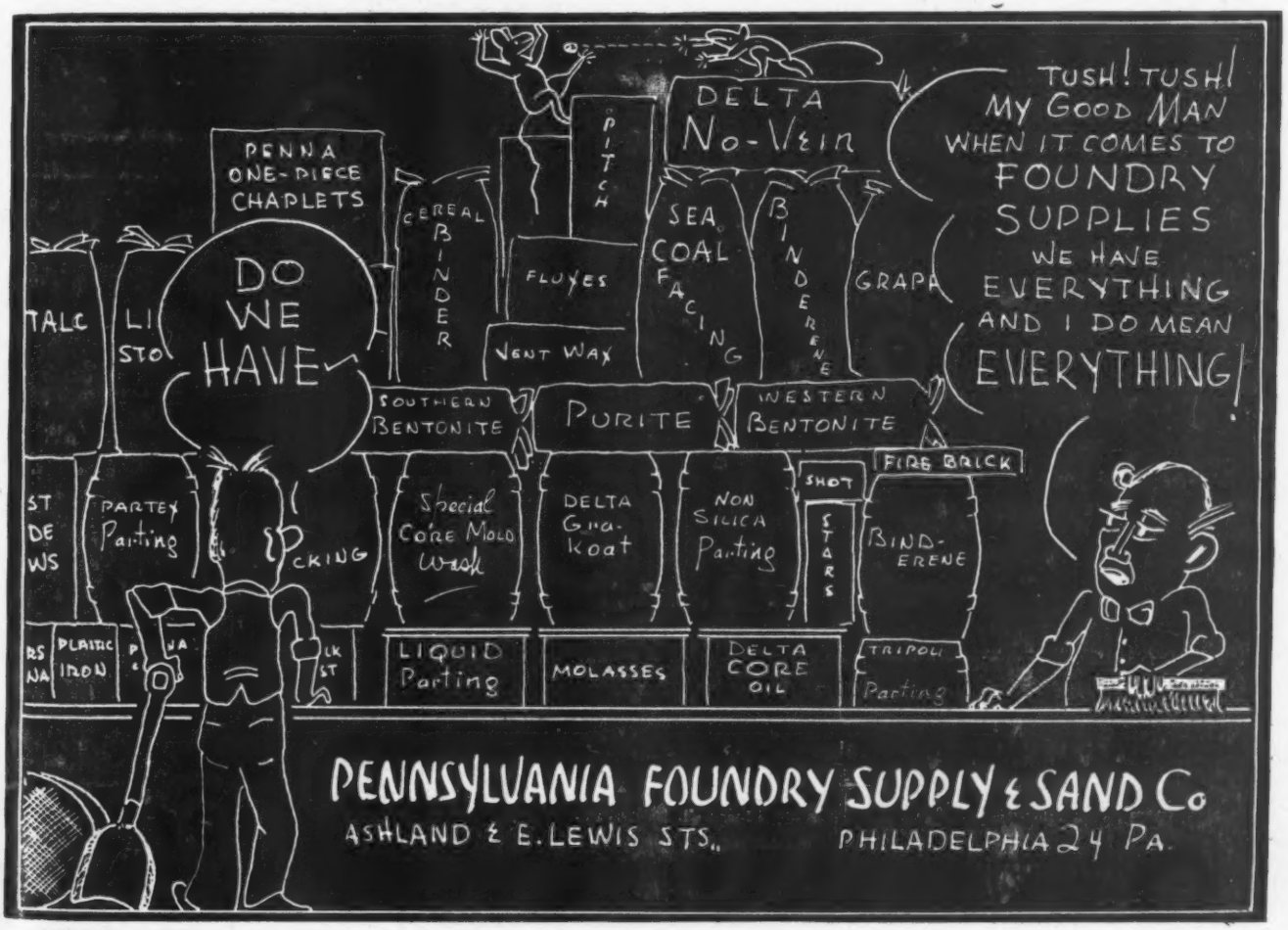

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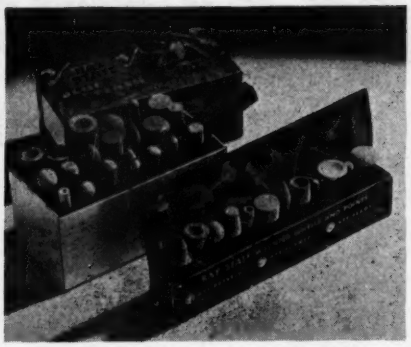
NEW EQUIPMENT

(Continued from page 102)



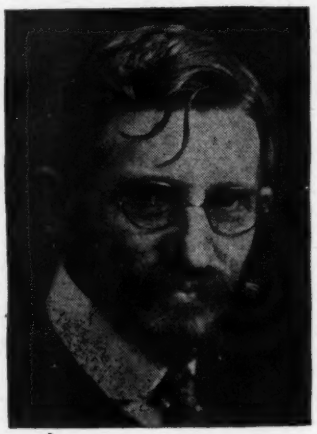
Utility grinding sets of 12 and 20 points most commonly used in industrial firms.

Resin Adhesive

Pennsylvania Coal Products Co., Petrolia, Pa., has announced a new product identified as Penacolite G-1215, a resorcin based adhesive. Due to its adhesive quality it can be applied to wood, plastics, fabrics, leather and rubber.

H. M. Lane, A.F.A. Life Member, Dies

HENRY M. LANE, affiliated with the foundry industry for over 50 years, died August 8 in Detroit at Grace Hospital after a brief illness. He was 77 years old.



H. M. Lane

His industrial activities, over the years, included writing, editing and

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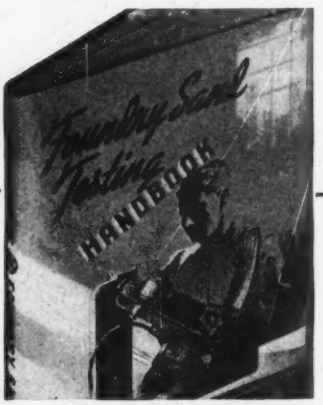

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investigating foundry problems. His research on sand and core oven operation and construction opened up new foundry fields. He served as editor of THE FOUNDRY at the turn of the century. Also served as manager of exhibits at the annual American Foundrymen's Association foundry shows 1906-08. Prepared the shop instruction courses for a correspondence school and aided in designing many prominent foundries, acting as consultant. Journeyed abroad and introduced American foundry methods to the Citroen plant in France. Was a member of the American delegation in 1923 that attended the International Foundry Congress in Paris.

The Association, in 1941, elected him an honorary life member at the 46th Annual Convention held in New York City during May. He was awarded this life time membership in recognition of long and continued service and early pioneering work in the technical development of the foundry industry.

Statement of Ownership

Statement of the ownership, management, circulation, etc., required by the acts of Congress of August 24, 1912, and March 3, 1933 of AMERICAN FOUNDRYMAN, American Foundrymen's Association, published monthly at Chicago, Ill., for October 1, 1945, State of Illinois, County of Cook, ss. Before me, a notary public in and for the state and county aforesaid, personally appeared Wm. W. Maloney, who, having been duly sworn according to law, deposes and says that he is the Editor of the AMERICAN FOUNDRYMAN, American Foundrymen's Association, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, to-wit: 1—That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, American Foundrymen's Association, Inc., Chicago, Ill.; Editor, Wm. W. Maloney, Chicago, Ill.; Managing Editor, N. F. Hindle, Chicago, Ill.; Business Managers, None. 2—That the owner is American Foundrymen's Association, Inc., not for profit; stock, none. Principal Officers: Fred J. Walls, President, International Nickel Co., Detroit, Mich.; Wm. W. Maloney, Secretary, Chicago, Ill. 3—That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: None. 4—That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him. Wm. W. Maloney, editor. Sworn to and subscribed before me this 1st day of October, 1945. (Seal) Jennie Reininga, Notary Public. (My commission expires Feb. 9, 1946.)

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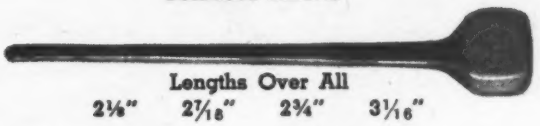

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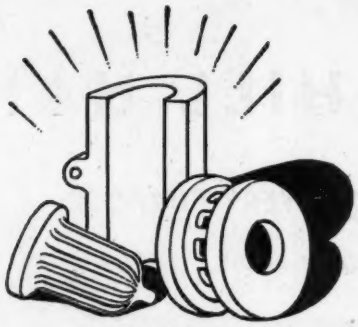

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ENCLOSED TIP

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